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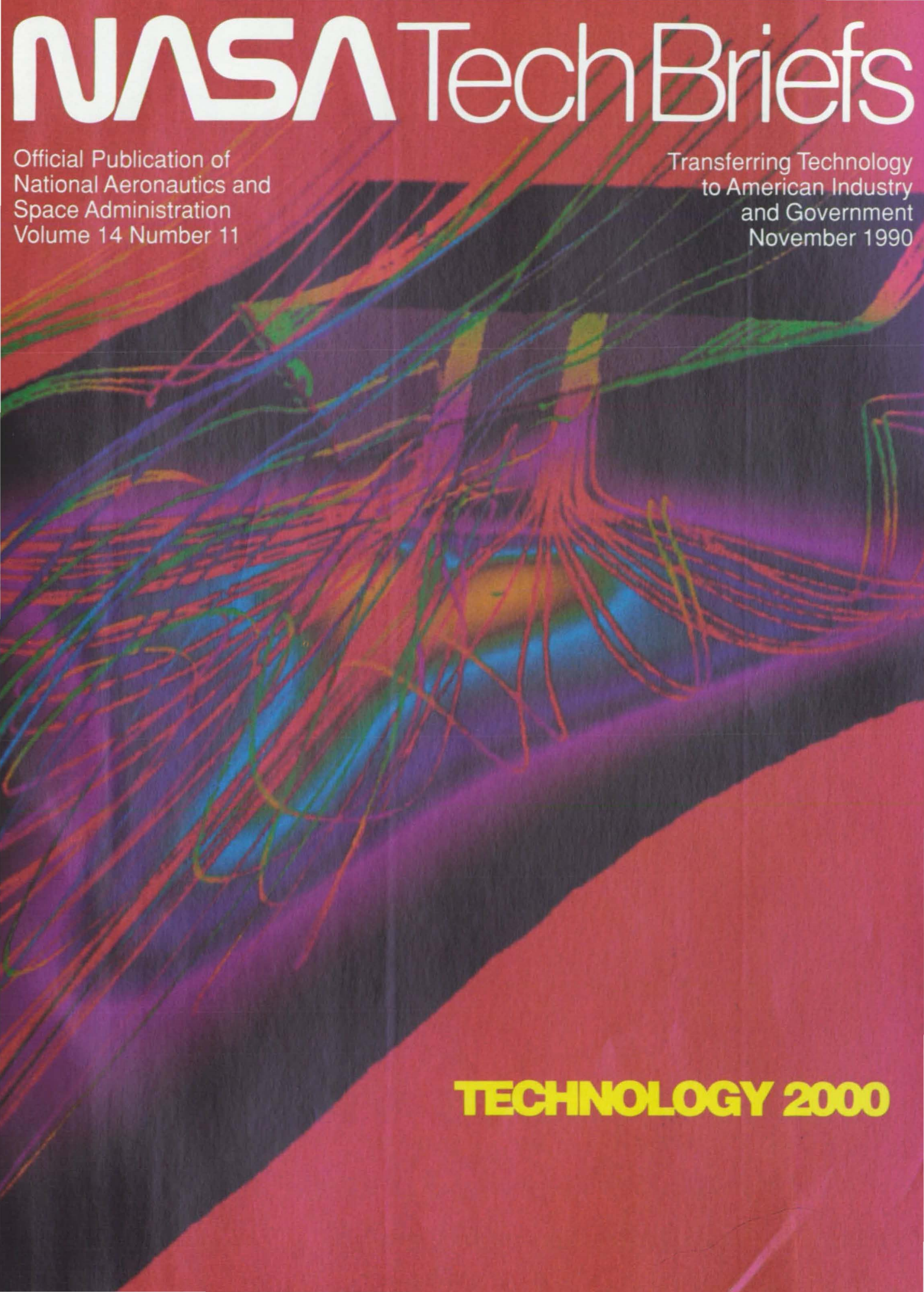
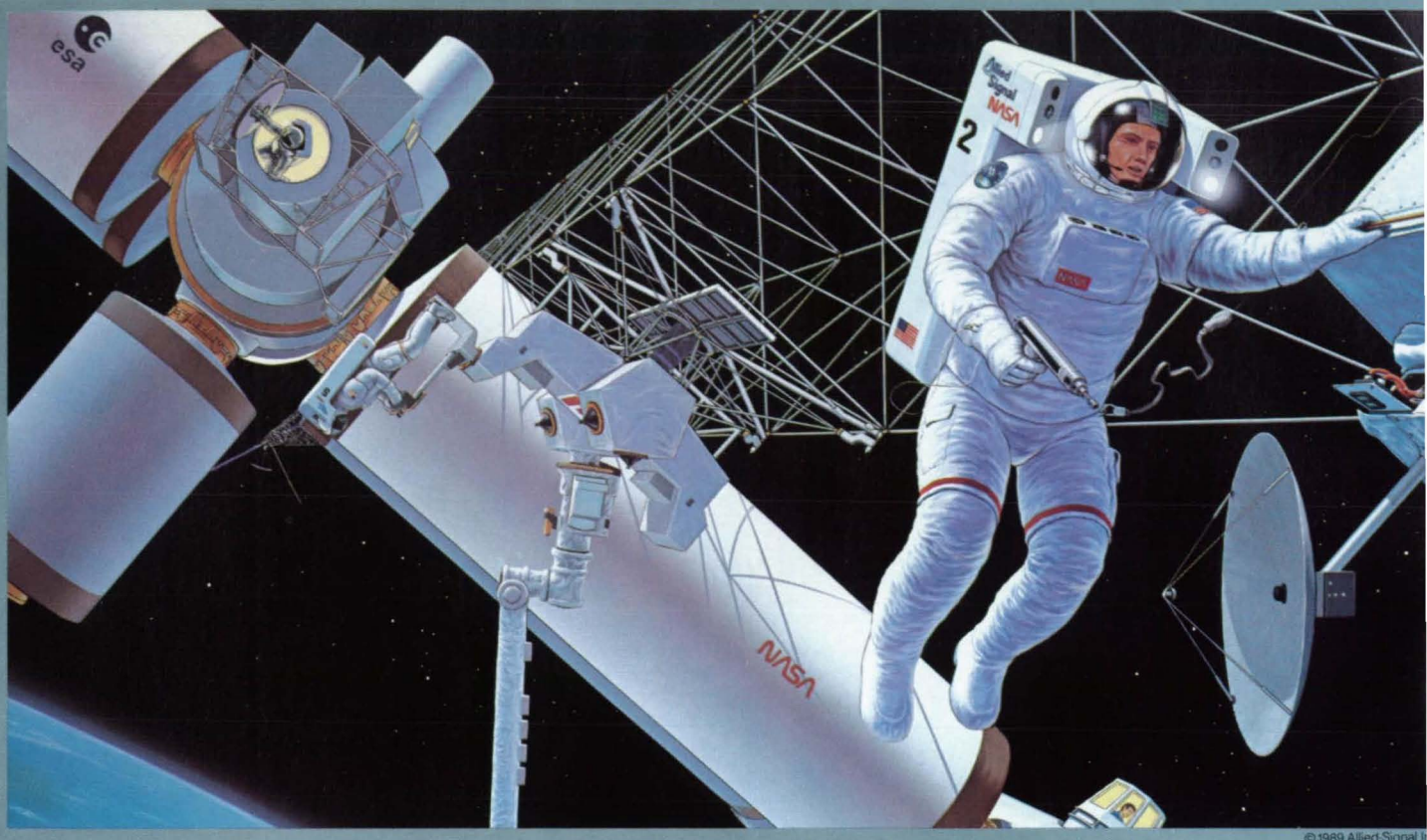
Volume 14 Number 11

Transferring Technology
to American Industry
and Government
November 1990



TECHNOLOGY 2000



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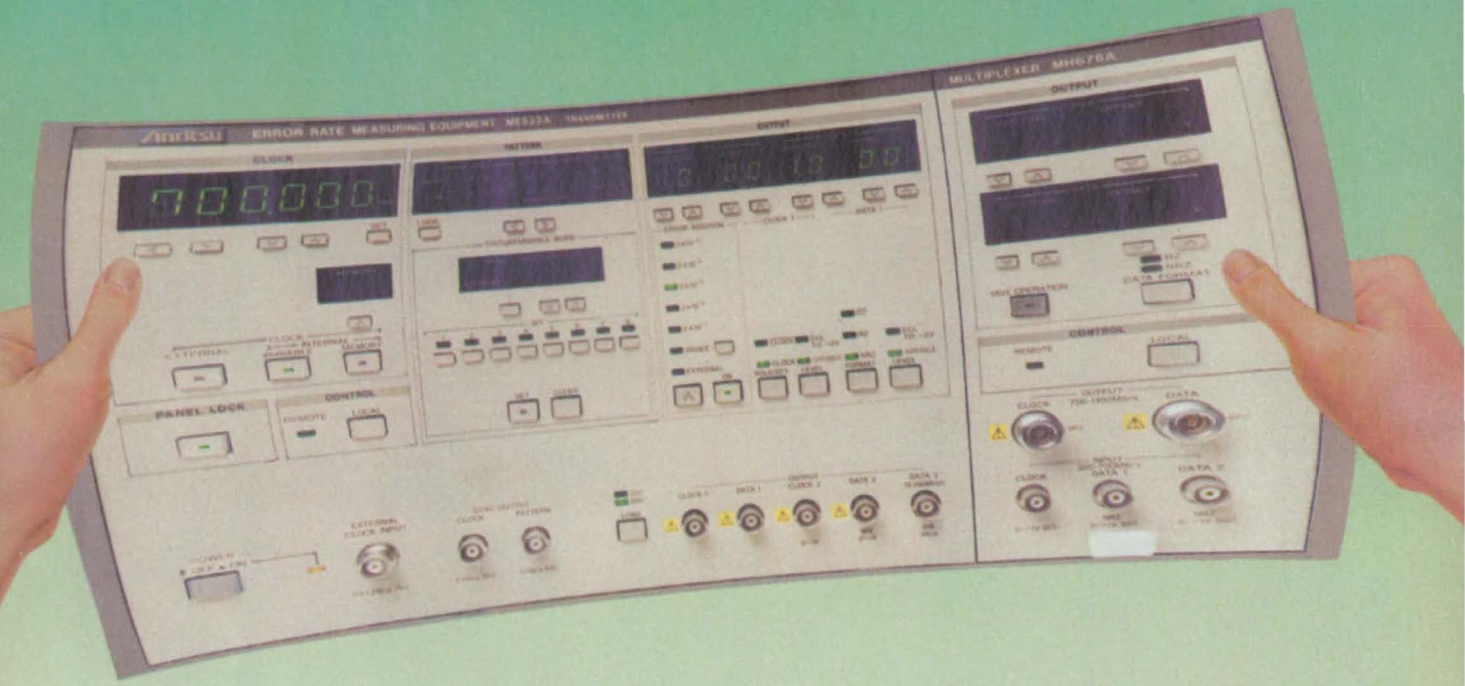

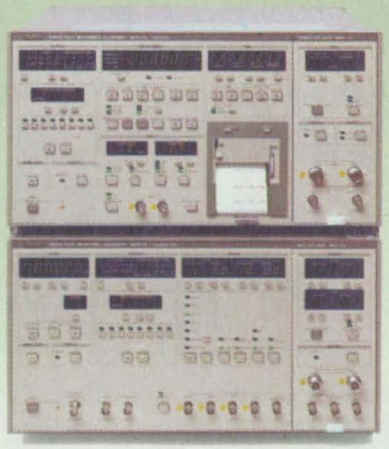

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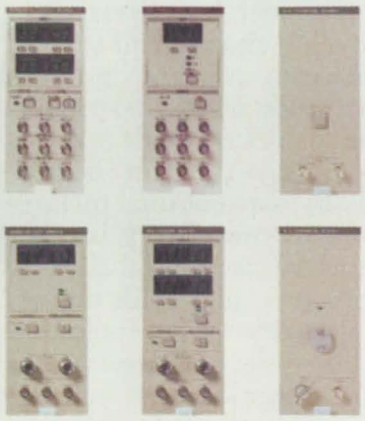

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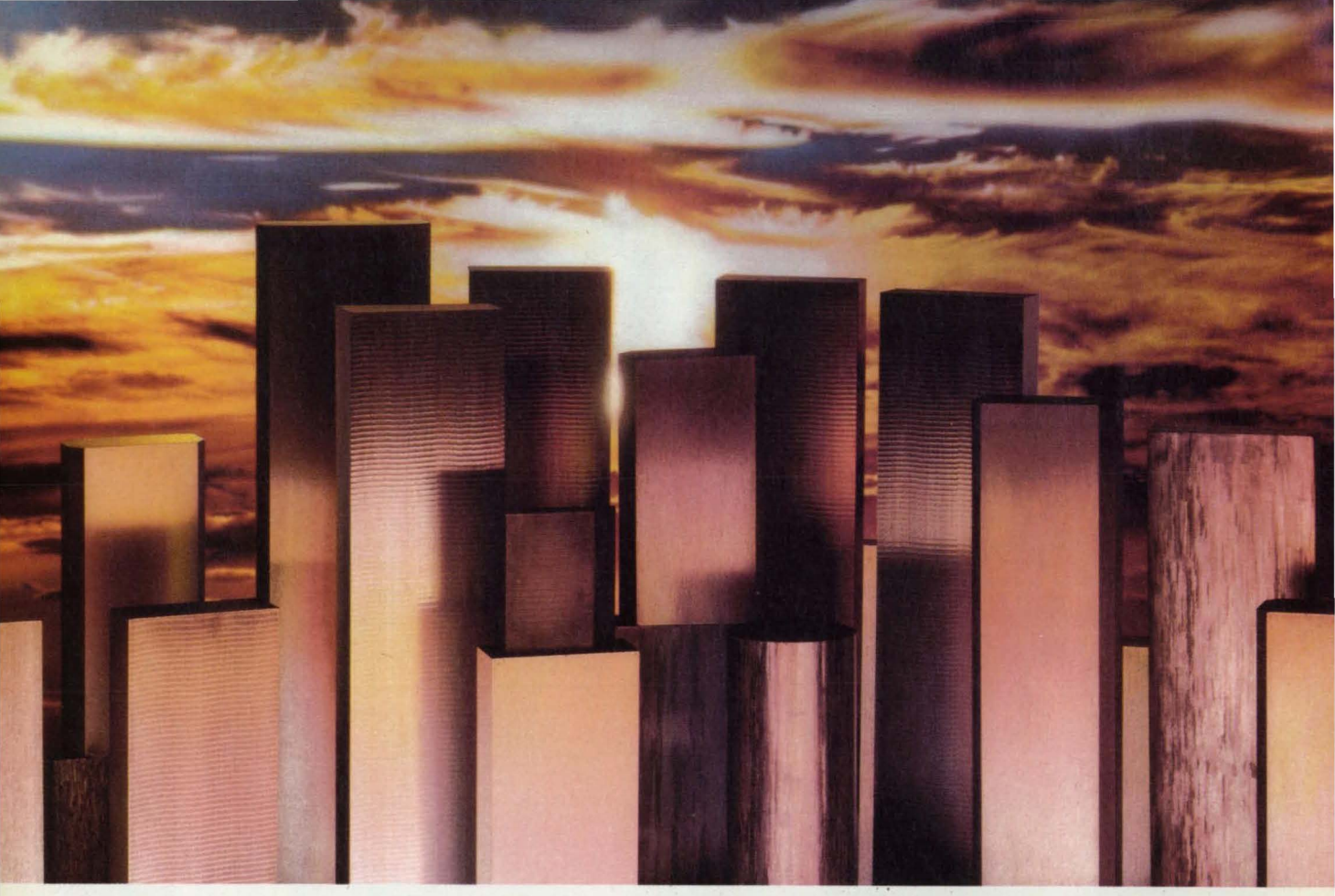

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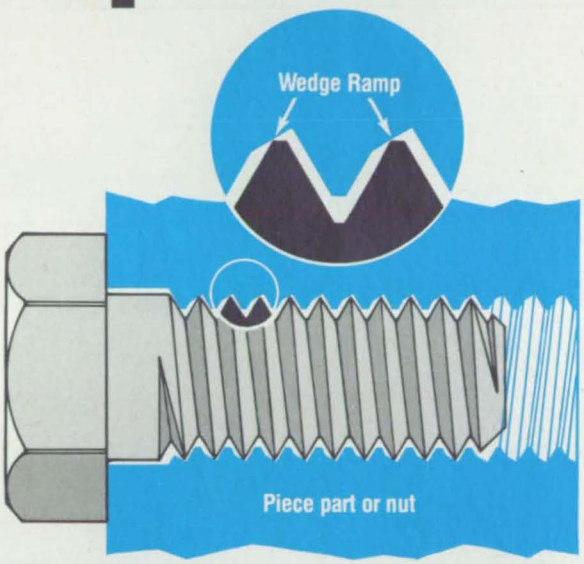

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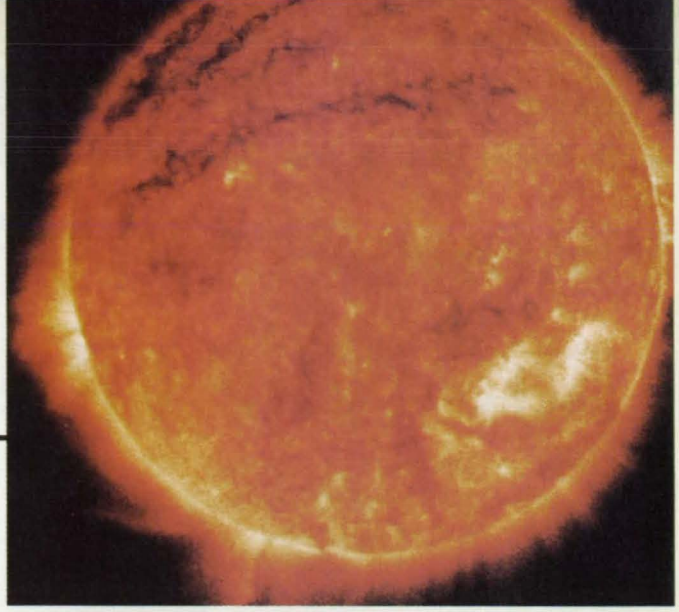

Photo courtesy Marshall Space Flight Center

NASA/Stanford University researchers used a multilayer Cassegrain x-ray telescope to capture this image of the solar corona at 1,000,000 K. The research team is now developing a high-resolution x-ray microscope for cancer studies.
Turn to page 10.

SPECIAL FEATURES

TECHNICAL SECTION

DEPARTMENTS

On The Cover: This issue spotlights Technology 2000, NASA's first national technology transfer conference and exhibition (November 27-28, Washington, DC Hilton Hotel). Symposia will cover a broad array of government-sponsored innovations available for commercialization, in such fields as biotechnology, robotics, optics, materials science, and computational fluid dynamics (CFD). The cover CFD image shows a Delta with thrust reverser jets in ground-effect.
(Photo courtesy Ames Research Center)

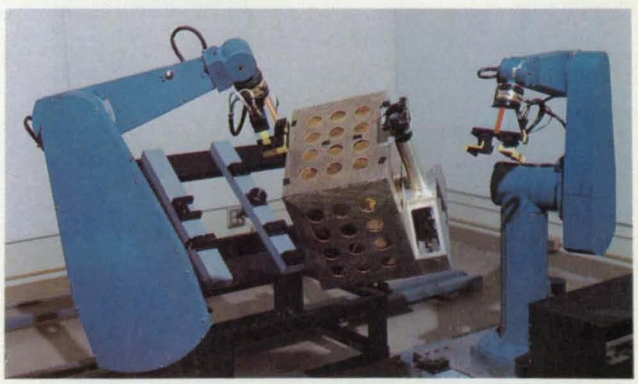

Photo courtesy Jet Propulsion Laboratory

A new test bed for space robots could be adapted for developing terrestrial telerobots to handle radioactive materials, dangerous chemicals, and explosives. ***See page 46.***

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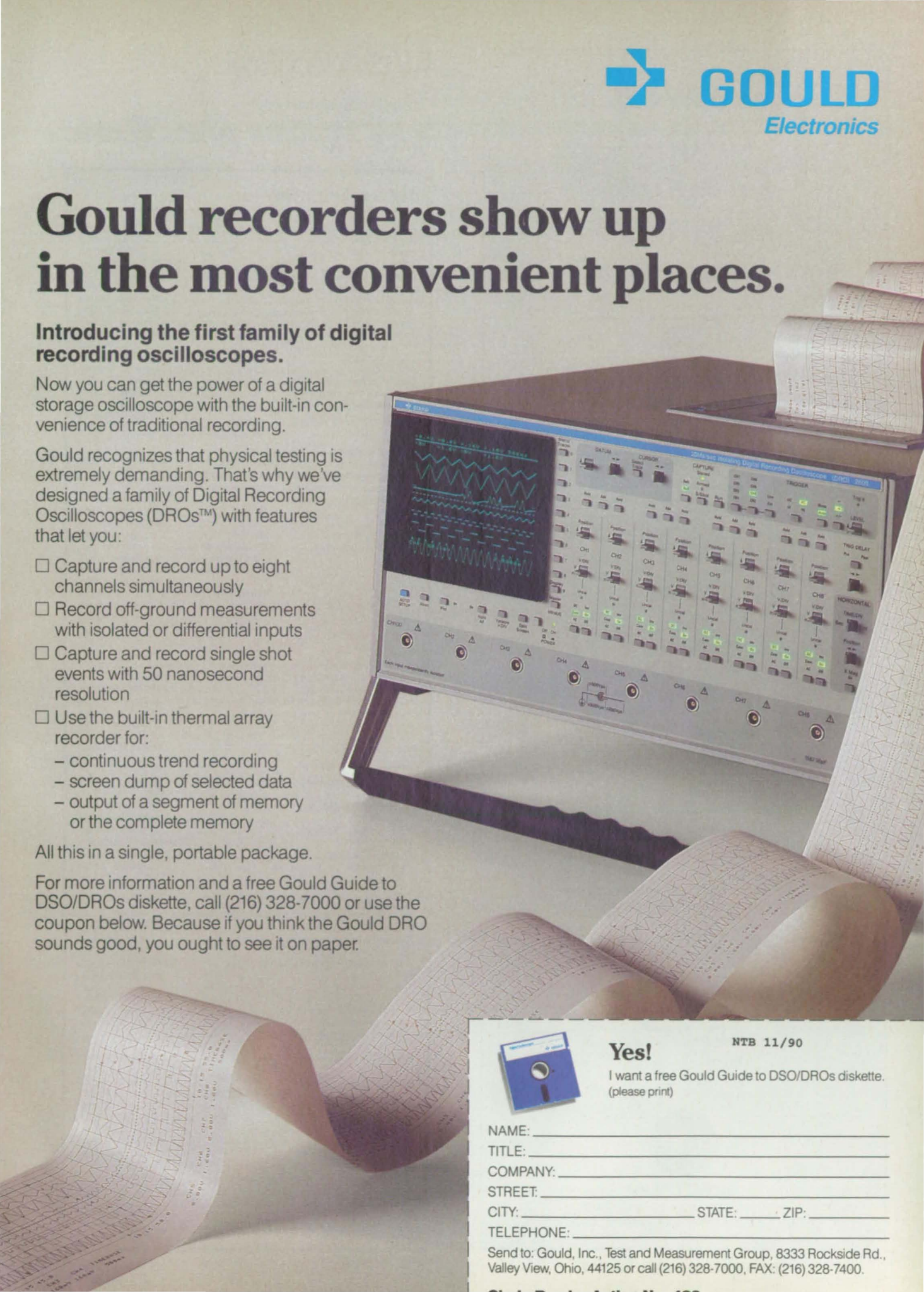

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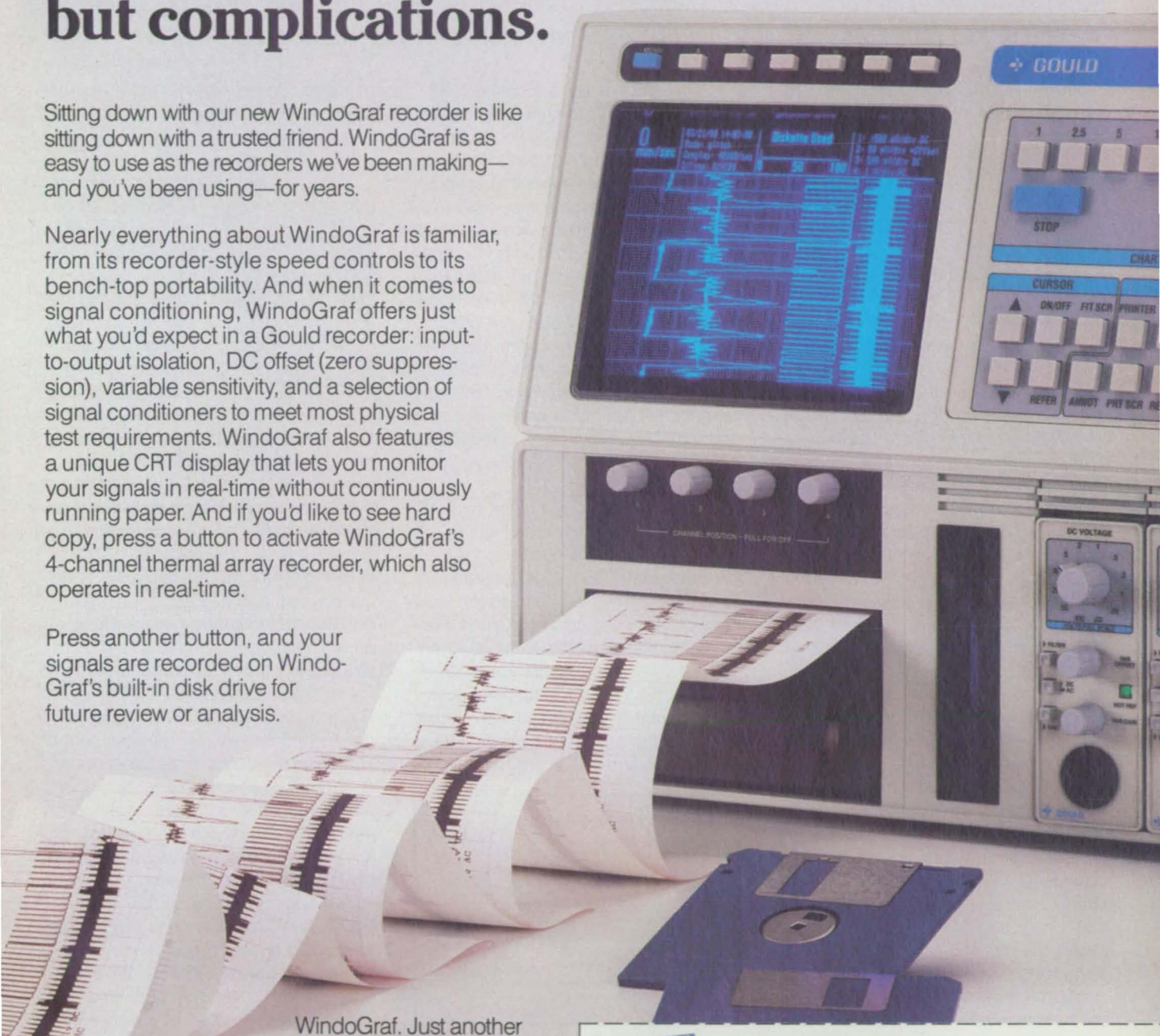

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NASA's Innovators

Technology 2000, NASA's first-ever national technology transfer conference and exhibition (November 27-28, Washington, DC Hilton Hotel), will feature presentations by over 100 of the agency's top researchers, describing a wide array of space-based technologies with down-to-Earth applications in such fields as electronics, materials science, and biotechnology. In the second of two parts, we look at some of these innovators and their leading-edge work.

James E. Dudenhoefer heads a 26-member team at NASA's Lewis Research Center developing free-piston Stirling engine technology for future space power needs. Efforts are focused on increasing system electric and thermal energy conversion efficiency at least five-fold over current SP-100 technology, and on developing systems that are compatible with space nuclear reactors.

NASA's space power technology historically has concentrated on systems delivering less than 10 kW. These power requirements have been met almost exclusively by photovoltaic (PV), RTG, and electrochemical storage systems. "Over the next several decades, the amount of electric power in space will grow immensely," Dudenhoefer stated. Tomorrow's space platforms will require continuous power of hundreds of kilowatts, he said, and some duty cycles will periodically consume many megawatts. These platforms will include manned space stations, communication stations, and surveillance platforms.

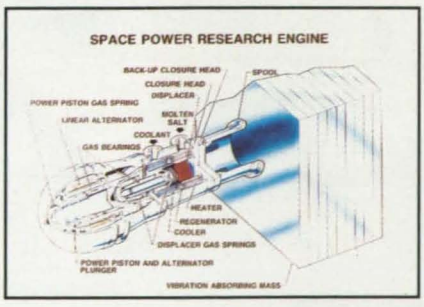
The free-piston Stirling is a rapidly emerging technology which has attracted considerable attention due to the successful 25 kW Space Power Demonstrator Engine. A recent study indicated that it may be possible to build a free-piston Stirling engine/linear alternator system with up to 500 kWe per cylinder. "Less than five years ago it was considered a major achievement to build and successfully operate a 3 kWe Stirling engine," the Lewis researcher said.

The free-piston Stirling has the potential to be a highly reliable engine with long operating life, according to Dudenhoefer, because it has only a few moving parts, noncontacting gas bearings, and can be hermetically sealed. Further, it uses nuclear energy rather than heavy fuel, significantly decreasing its cost.

"Stirling is the new kid on the block," he said. "It must prove itself under the shadows of the bigger kids—the Bryton and Rankine (dynamic power systems). Stirling's main advantage is that it's lighter and more efficient than these systems."

Lewis began Stirling system research in 1977 when the Environmental Protection Agency sought an alternative automotive engine to conserve energy and preserve the environment. With its external combustion system, the kinematic Stirling engine cleanly burns virtually any fuel and delivers high mileage per gallon. A prototype system was successfully demonstrated in United States Air Force and Postal Service vehicles driven across the country.

Currently, Cummins Engine Co., Stirling Technology Corp., and the Department of Energy are combining the 25 kW free-piston Stirling cycle electricity generator with a parabolic mirror solar heat concentrator to produce an economical solar-powered electricity generator for terrestrial applications. Such units could be used for "topping" power cycles by utilities, especially in the Sunbelt, Dudenhoefer said. They will also have tremendous potential in the Third World,



much of which lies in tropical areas with lots of available sunshine.

Dudenhoefer joined NASA after receiving a BA in electrical engineering from Gannon University. He had planned to stay with the agency for three years. That was in 1965. "It gets into your blood," he said. "At NASA I have the opportunity to explore technology, make mistakes, be innovative, and affect the world we live in."

Over the past two decades, **Richard B. Hoover** has developed an array of advanced x-ray imaging systems to probe the mysteries of space. Hoover, an astrophysicist at the Marshall Space Flight Center's Space Science Laboratory, is currently principal scientist for the Ultra-High-Resolution XUV Spectroheliograph experiment, a group of multilayer x-ray telescopes selected for flight on space station Freedom. He began work in x-ray optics in 1967, developing x-ray mirrors for a SKYLAB experiment, and has designed grazing and normal incidence x-ray telescopes and microscopes, as well as hybrid instruments. Further, he was coinvestigator for the Stanford/Marshall Center X-Ray Spectroheliograph, which provided the first high-resolution images of the sun using multilayer x-ray telescopes.

Now Hoover is applying his space-based imaging techniques to develop a new tool to study the workings of the human body. He is spearheading the design of a doubly-reflecting, multilayer x-ray imaging microscope for cell biology studies. The instrument, which could greatly aid cancer researchers, is configured to operate within a narrow regime of the x-ray spectrum that lies between the K absorption edges of oxygen and carbon. In this "water window," carbon is highly absorptive and water is highly transmissive. Therefore, the microscope should be able to delineate—with high spatial resolution and contrast—carbon-based structures within living cells. "It would allow researchers to examine living cells without using dyes, stains, or exogenous chemicals which produce limiting artifacts," said the 47-year-old scientist.

"Our theoretical analysis has shown that multilayer x-ray microscopes of the Schwarzschild or aspheric configurations should be able to achieve spatial resolution in the 100 angstrom range or better," Hoover stated. Such performance should permit direct imagery of cytoskeletal membranes, secretory vesicles, chromatin, nucleoli, and nucleosomes, he explained, and should improve diagnonis and benefit experimental studies of tumor cell biology. Ultimately, advanced versions of the x-ray microscope could achieve high enough spatial resolution to resolve pure DNA and RNA molecules within living tumor cells.

Hoover expects the project to be completed by 1992, if further funding can be secured from NASA and the American Cancer Society.

Hoover's other interests include paleontology and micropaleontology. He is internationally known for his work with diatoms. At the invitation of the Royal Zoological Society of Antwerp, Belgium, he researched their diatom collection and produced serveral thousand photomicrographs. "It was like a music student being told 'there's some unpublished work by a fellow named Mozart and we want you to evaluate it,'" he said. Many of Hoover's photomicrographs were published in *National Geographic*, and some are now on display in the Smithsonian Museum of Natural History.

"I like to see the tremendous capability NASA has as a technology agency brought to bear on important scientific questions," said **Dr. Wayne E. Esaias**, an oceanographer at Goddard Space Flight Center, Greenbelt, MD. A NASA employee since 1979, Esaias specializes in the use of satellite observations of ocean optical properties (ocean color) to understand the role of marine algae in the global carbon and primary productivity cycles. He is project scientist for the SeaWiFS—a satellite which will make global ocean color observations beginning in 1993. He is also active in ocean remote sensing aspects of NASA's Earth Observing System (EOS). Slated for launch in 1998, EOS orbiting platforms will study changes in the Earth's system in an effort to understand global warming and other environmental concerns.

Since 1986, Esaias has been researching and developing the Ocean Data Acquisition System (ODAS), a low-cost instrument which can be easily mounted on a small aircraft and flown over the coastal zone ocean to remotely measure sea surface temperature and three channels of ocean color information. From this data, chlorophyll levels can be derived for use by ocean scientists, fisheries, and environmental offices. Data can be transmitted to ships for real-time use with sea truth measurements, ocean productivity estimates, and fishing fleet direction.

The aircraft portion of the system has two primary instruments: an infrared radiometer to measure sea surface temperature and a three-channel visible spectro-radiometer for 460, 490, and 520 nm wavelength measurements. The output of both instruments is fed into a data system, digitized to 12-bit resolution, formatted, recorded on board, and transmitted to a receiving system for processing. The aircraft package includes a Loran-C unit for aircraft location information. From the measurement altitude of 500 feet, the line of sight transmitter range to a ship is about 30 miles.

The shipboard package contains a transceiver packet terminal controller, data processing capability, a cassette tape recorder, and a printer. Both raw data and chlorophyll concentrations are available for real-time analysis.

To keep down the cost of reproducing the instrument, Esaias' team used commercially-available subsystem components such as modified amateur transceivers for the data transmission systems and rack-mountable PCs for the data systems. "One of the main technological challenges was integrating the off-the-shelf components to meet system requirements," said Esaias, who holds a PhD in biological oceanography from Oregon State University.

ODAS has been used most extensively with the NOAA Chesapeake Bay program, but also in NASA missions in the North Atlantic, Iceland, and off Brazil. "The accuracy of pigment concentrations from the instrument is quite good even in complex Chesapeake Bay waters," said the Goddard researcher.

Prior to joining Goddard's ocean research program, Esaias served a two-year tenure as the ocean color program manager at NASA Headquarters, where he helped set the direction of the agency's present program. He is most proud, however, of his work on processing and analyzing remote sensing data to obtain the first global view of ocean phytoplankton.

Anne H. Johnson, a research microbiologist at NASA's Stennis Space Center in Mississippi, directs several projects dealing with the development of bioregenerative technology for closed systems. Though targeted for long-duration space missions, the technology offers a host of potential terrestrial applications, including improved wastewater treatment systems.

One project, dubbed the BioHome, is a unique bioregenerative habitat with a self-contained waste treatment and water reclamation system. The 650-square-foot model habitat is divided into two regions, one housing a wastewater treatment facility and the other devoted to living quarters for one individual.

One BioHome experiment uses plants and microorganisms to purify wastewater. Testing is concentrated on wetland plant systems, particularly bulrush and cattails, and their ability to remove pathogenic bacteria from wastewater.

"We want to ascertain the efficiency of these systems in breaking down and removing pathogens for both Earth and space applications," Johnson said. Previous research has shown that roots of aquatic plants such as bulrush and reed excrete substances that can partially or completely kill pathogenic bacteria without harming beneficial bacteria. The aerobic zone around the aquatic plant root system can also support the growth of protozoa which feed on bacteria, viruses, and particulate organic matter.

Johnson, who joined NASA in 1989 after graduating from the University of Southern Mississippi with a Master's Degree in microbiology, is also evaluating the ability of foliage plants such as golden pothos and spider plants to remove toxic organics from ambient air. "We've been doing studies to determine the organic breakdown mechanism, whether it's the plant, microorganism, or the combined activities of both," she explained. "We know there's something similar occurring in the plants we've screened, but we have much more to learn about their physiology in order to understand the overall mechanism."

Related research examines the possibility of producing food from plants and fungi within a closed system while obtaining drinking water from the process of evapotranspiration. As plants die within the wastewater system they are used for compost to grow vegetables.

Vegetables growing in the BioHome

Thus, this technology provides the potential for air and water revitalization as well as food production using strictly biological means. Food plants such as tomatoes, corn, potatoes, and squash have been successfully grown on composted aquatic plant materials produced in a similar wastewater treatment process, according to Johnson.

Plant filtration systems loosely based on those being tested by NASA have been marketed in the private sector. "It's a lucrative business, but we are interested in understanding the science behind the technology," Johnson stated. "The more we know, the more the transfer of this technology will be enhanced."

NASA veteran **John D. Buckley** has developed an innovative method for joining composite aerospace structures. Buckley's invention is a handheld toroid magnetic heat induction gun that produces fusion welds in thermoplastic materials. The technique is similar to that used for spot welding in metallic structures.

The lack of a practical joining methodology has hindered the use of composite materials in aerospace manufacturing. Conventional methods used in manufacturing advanced composite aerospace structures are labor and equipment intensive. They include preimpregnation of fiber reinforcement systems, cutting and hand layup of resin impregnated tapes, vacuum bagging, autoclave curing, debagging, and trimming. Joining methods involve mechanical fasteners and polymeric adhesives. Some of these adhesives emit toxic fumes during the polymerization stage and require up to 24 hours to react, while others require heat and pressure.

Buckley's toroid joining gun is a low-cost, low-power (100-400 watts) welding device which can be handheld, similar to a riveting gun. Composite parts can be joined in situ, whether on Earth or on a space platform.

"We began looking at it for assembling components in space because it doesn't require any water cooling, uses solar energy, and is highly portable," explained Buckley, a senior research engineer at NASA's Langley Research Center in Hampton, VA.

The invention allows for applying heat directly to the bond lines and/or the adherends without heating the entire structure, supports, and fixtures of a bonding assembly. In bonding fiber-reinforced thermoplastic composites with the plastic welder, a thin film of the matrix polymer and a thin stainless or carbon steel screen wire susceptor are placed between two adherends. The screen wire is used to concentrate heat at the joint to provide additional reinforcement. If the fiber reinforcement in the composite is conductive, such as graphite, the steel screen wire may be eliminated.

When power is applied, the toroid rapidly heats the joint to the melt or glass transition temperature of the matrix thermoplastic, thereby lowering its viscosity enough to cause flow and wetting at the adherend surfaces. Upon rapidly cooling below the melt temperature of the adherends, the joint is complete. The bonding cycle requires approximately two to four minutes for joining graphite-reinforced high-temperature thermoplastics with adherend thicknesses of 0.125".

When using the plastic welder to bond fiber reinforced thermoset composites, a thin thermosetting film or coat of thermosetting adhesive must be used between the adherends. The toroid rapidly heats the thermoset joint to the temperature at which the adhesive polymerizes. The joint is then rapidly cooled.

Bonding times for laboratory specimens have been cut by a factor of 10 to 100 times compared to standard press or autoclave bonding, according to Buckley, who has worked at NASA since 1959.

Potential terrestrial applications include wall construction, electrical connections, and plumbing. It has also been used to put band saw blades together and to fix plastic canoes and boats. Buckley expects a commercial version to reach the market in a few years.

Editor's note: Beginning in February, NASA's Innovators will become a regular bimonthly feature in NASA Tech Briefs.

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Stop by our Booth #402 at Technology 2000,

Circle Reader Action No. 620

Technology 2000:

A Showcase Of High-Tech Inventions

Meet a robot farmer, experience "virtual" 3D sound, and match wits with an "expert" computer. These are but a few of the leading-edge inventions NASA field centers will demonstrate in the Technology 2000 exhibit hall.

Liquid Air Pack
Originally designed for astronaut rescue, the Liquid Air Pack could provide firefighters with additional breathing time in emergency situations. By employing liquid air rather than conventional high-pressure gaseous air, this self-contained breathing apparatus provides twice as much air as gaseous systems while maintaining weight and minimizing profile.
Kennedy Space Center
Booth Number 739

Intelligent Physics Tutor
An "expert" computer system is helping high school students to learn math. Using artificial intelligence technology developed for flight controller training, the Intelligent Tutoring System for High School Physics drills students with physics problems, providing the teacher with more time for one-on-one instruction. The technology can be easily adapted for chemistry or computer science tutoring systems.
Johnson Space Center
Booth 516

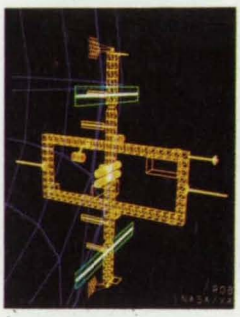
Temperature Pill
An ingestible thermometer capable of measuring and relaying deep internal body temperatures promises improved patient care in hospitals and opportunities in medical experimentation. The three-quarter-inch capsule, which contains a telemetry system and quartz crystal temperature sensor, provides a way to quickly detect dangerously low (hypothermia) and high (hyperthermia) body temperatures. It also offers applications in fertility monitoring, obstetrics, and food processing research.
Goddard Space Flight Center
Booth 412

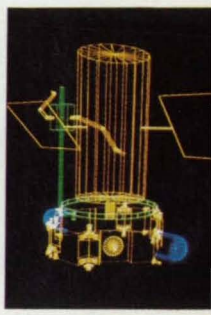
Electro-Expulsive Deicing System
This award-winning invention uses pulses of electricity to fracture and expel ice accumulation on aircraft and ships. The system, which consists of an elastomeric boot embedded with flexible conducting ribbon, can remove mere frost to a one inch glaze in less than a thousandth of a second. It requires one thousandth of the power and one tenth the weight of present thermal deicers and pneumatic boots, and can be retrofitted to most aircraft.
Ames Research Center
Booth 728

Computer-Aided Design of Artificial Hearts
NASA scientists have used computational fluid dynamics (CFD) techniques to simulate the blood flow through a Penn State artificial heart. The computer model will help medical researchers to better understand the heart's complex flow field and should lead to improved pump designs.
Ames Research Center
Booth 728

Cooling Suit
Children born without sweat glands who risk heat stroke with physical exertion can now lead more normal lives thanks to a NASA-originated cooling suit. An antifreeze solution chilled by a portable, battery-powered refrigeration unit is pumped through tubes to the vest and helmet liner, which are made of a special temperature-sensitive fabric. Factory workers, military personnel, and race car drivers also wear the suit to stay cool.
Langley Research Center
Booth 315

ROBOSIM
Students and high-tech professionals learn firsthand about robotic technology through ROBOSIM, a low-cost simulator of robotic systems. Created





by NASA to aid in the rapid prototyping of automation, ROBOSIM has enabled the development of improved robotic concepts for both Earth-based and proposed on-orbit applications.
Marshall Space Flight Center
Booth 417

Flexible Agricultural Robotic Manipulator System (FARMS)
The nursery and greenhouse industry could increase productivity with a robotic system to handle and process plant material. NASA is developing technologies for an integrated robotic workcell, including supervisory control, machine vision, and tactile sensing devices.

Marshall Space Flight Center
Booth 417

Prosthetic Devices for Amputees
Using space-based robotics techniques, Marshall Center researchers

are developing improved end-effectors for hand and below-the-elbow amputees. The group is designing a lightweight rotationally-actuated device without the usual shoulder harness, which is often uncomfortable. Other devices in the works include a fishing reel crank turning mechanism and a nail holder for carpentry work.
Marshall Space Flight Center
Booth 417

X-Ray Technique for Environmental Monitoring
An x-ray fluorescence spectrometer system used for analysis of Martian soil samples has been adapted for monitoring water quality and toxic wastes on Earth. The portable instrument can screen over 50 chemical elements, with priority given to toxic heavy metals, and can detect concentrations as low as 50 parts per billion.
Langley Research Center
Booth 315

Ultrasonic Burn Depth Monitor
Burn depth detection no longer depends solely on the burn surgeon's experience and skill. Langley Research Center has developed an ultrasonic device that makes quantitative measurements of burn depth in humans by sensing the difference in sound pulses between burned and normal skin tissue. The technique has provided clinically-reliable results for patients suffering scald, flame, and chemical burns.
Langley Research Center
Booth 315

Air Conditioning System for Radon Control
A special air conditioning system uses 100 percent fresh air to ventilate a house in order to combat radon and other airborne contaminants. The machine employs heat pipe technology to exchange both sensible and latent heat, and can be coupled with a vapor compression heat pump to provide treated air to the house.
Kennedy Space Center
Booth 739

Smart Hydrogen Sensor
NASA has combined a compact digital signal processing computer and advanced sensors to create an intelligent hydrogen detection system with near-real-time predictive capabilities. Its unique algorithm utilizes input from a variety of sensors to determine environmental correction factors in order to prevent false positive or negative readings.
Stennis Space Center
Booth 742

Gamma-Ray Collimator
A unique gamma-ray collimator built at NASA Stennis can house 200 curies of Cobalt 60 during actual radiographic exposures while reducing radiation in unwanted directions from 200 to 0.5 curies. The collimator also mitigates undesirable backscatter, improving the radiograph's quality and sensitivity.
Stennis Space Center
Booth 742

Microtronic Flow Transducer
Nurses can monitor the breathing of newborn infants with the Microtronic Air- and Gas-Flow Transducer, an outgrowth of NASA's research on deep impurities in silicon. Unlike other gas-flow meters and transducers, this device has no moving parts and can be constructed using a variation on the ordinary technology for processing planar silicon microelectronics. It can be applied to monitor patient breathing in hospitals and to control anesthetic gases during surgery.
Lewis Research Center
Booth 312

Tympanic Thermometer
An innovative thermometer developed at JPL determines a patient's temperature by measuring the infrared radiation emitted from the bottom of the ear canal. It can gauge the patient's temperature in under two seconds and can be used on critically ill or incapacitated patients, as well as newborns.

Jet Propulsion Laboratory
Booth 523

"Getaway Special" Canister
Under the "Getaway Special" Program, researchers can place small scientific payloads on board the space shuttle, where they are housed in NASA-supplied cylindrical canisters. After exposure to the space environment, the payload is returned to Earth for analysis. The program is designed to stimulate broader interest in scientific research among the large segment of the scientific community not engaged in development of primary payloads.
Goddard Space Flight Center
Booth 412

Transportable Applications Environment
What You See Is What You Get (WYSIWYG) with the TAE™ Plus user interface development and management system. The portable system provides an integrated software environment for interactive prototyping and development of graphical user interfaces.
Goddard Space Flight Center
Booth 412

Three-Dimensional Acoustic "Visualization"
Developed for NASA's Virtual Workstation, the Convolvotron is a high-speed digital signal processing system that enables three-dimensional sound reproduction. Wearing standard headphones, the user can locate, in space, up to four independent and simultaneous sound sources. Applications include virtual reality, flight simulation, and hearing research.
Ames Research Center
Booth 728

Technology 2000 Exhibitor Directory

BOOTH

Aerospace Lubricants Inc. 511
Columbus, OH,
will showcase perfluoropolyether (PFPE) grease lubricants with operating temperatures ranging from -140° to +550°F. These lubricants are compatible with liquid and gaseous oxygen at high pressures, and most other highly reactive chemicals. All have low vapor pressures, with some capable of long-term operation at pressures of 10^{-12} torr.

Aerospatiale 633
Paris, France,
will exhibit high-temperature composite materials, fire protection and thermal protection composite applications, magnetic bearings, and superplastic forming and diffusion bonding.

Alabama Department of Economic and Community Affairs 419
Montgomery, AL,
will discuss high technology expertise available to Alabama businesses, and economic development assistance available from the state.

American Insights Inc. 623
Alexandria, VA,
will present *Gubser's Guide to University Research and Technology*, a detailed analysis of new developments in science and technology at America's top 156 research universities. It describes licensing opportunities for major new inventions in aerospace, materials science, biotechnology, robotics, optics, energy, and many other fields.

Ames Research Center 728
Moffett Field, CA
See page 14.

AMP Inc. 311, 313
Harrisburg, PA,
will feature three high-density interconnection products: Micro-Strip connectors that pack 40 high-speed signal lines and their associated grounds into a linear inch; a low-profile surface-mount production socket for JEDEC TapePak molded carrier ring devices; and a Conductive Carbon Fiber connector that connects two planar surfaces, such as flat panel displays and their driver boards.

Argonne National Laboratory 735,737
Argonne, IL,
focuses on basic research in the physical, biological, and environmental sciences, and on technology-directed research in fission, fossil, and fusion energy and conservation and renewable energy.

Arthur D. Little Inc. 216
Cambridge, MA,
will present two products: the Dexterous Handmaster, a high-precision exoskeleton which enables the monitoring of hand motions for either robotics slave/master control or medical evaluation; and a laundry system for space station Freedom to wash and dry clothes in microgravity with a small fraction of the water usage of conventional approaches.

BOOTH

Astro-Med Inc. 328
West Warwick, RI,
will exhibit the MT95000 chart recorder featuring 300 dot per inch resolution, 8-, 12-, and 16- channel configurations, menu-driven operation, frequency response of up to 20 kHz, and up to 2 megasamples of memory.

Carlson Technology Inc. 614
Livonia, MI,
designs, develops, and manufactures custom personal cooling systems for health care and industrial applications.

Carnegie Mellon University 428,430
Robotics Institute,
Pittsburgh, PA,
will display space-related robotic systems such as the self mobile spaceframe manipulator, shuttle ground servicing systems, and the Ambler planetary exploration robot.

Centera Technologies Inc. 309
Louisville, KY,
will display GRAFkit, a graphics package designed for scientific, engineering, and technical data display. It organizes multi-dimensional data to produce high-level graphics such as contours, 3D surfaces and solids, streamlines, and vectors.

Claritek 620
San Diego, CA,
will demonstrate a prototype of a transtelephonic ultrasonic transmission system called HeartLink™ which captures a full-motion real-time transmission of ultrasonic cardiovascular images. It has applications for medical diagnosis, linking with many major universities and medical centers nationwide.

Commodore Business Machines Inc. 528
Reston, VA
Commodore's Federal Systems Group will show the Amiga 3000 UX running AT&T's UNIX version 5.4 and the Amiga 2500/30 running 3D modeling programs.

Computer Sciences Corp. 524,526
Falls Church, VA

Corning Incorporated 227
Corning, NY
Corning's Technology Sales and Licensing Group will describe the company's analytical and engineering services and its patented technologies available for sale or license. This group also acquires and licenses outside technologies.

COSMIC 124
Athens, GA
NASA's Computer Software Management and Information Center will feature software programs in areas such as artificial intelligence, aerodynamics, CAD/CAM, communications, composites, heat transfer, image processing, optics, project management, and structural analysis.

BOOTH

County of Loudoun 628
Department of Economic Development
Leesburg, VA,
will display brochures and a video focusing on the advantages of doing business in Loudoun County.

Cybernet Systems Corp. 409
Ann Arbor, MI,
will display products resulting from recent Cybernet contract work to develop portable mobile robotics command centers, handheld computer applications, and teleoperated guided robotic systems.

Datatape Inc. 427
Pasadena, CA,
will display rotary digital and analog magnetic tape recording systems used for various military, aerospace, and commercial applications.

Defense Technical Information Center 612
Alexandria, VA,
will offer a handbook discussing how to make contributions of scientific and technical information in various formats to DTIC's collection, as well as a brochure describing the center's services.

Deltek Systems Inc. 501
McLean, VA,
will feature its Accounting and Job Cost software systems developed for the government contractor. The systems are used by more than 800 contractors in meeting accounting and informational needs, handling everything from detailed projects to automatic billing.

Design And Evaluation Inc. 410
Laurel Springs, NJ,
will display its Handbooks On Worst Case Circuit Analysis, the only publication instructing the engineer on how to perform the analysis according to DOD MIL-STD 785B, Task 206.

Detector Electronics Corp. 612
Minneapolis, MN,
will display a brochure describing the company's flame detection products and capabilities.

Dimension Technologies Inc. 518
Rochester, NY,
will display the DTI 100M, the first commercial product to provide autostereoscopic viewing. It is an LCD-based, 640 x 480 resolution, 16 gray level display driven from the IBM 286/386/486 family or Apple Macintosh II platform.

Dolphin Scientific Inc. 500
Long Beach, CA,
will demonstrate the Desktop Signal Processor, a system providing up to 450 MFLOPS in a small desktop configuration. Host computers include the Sun UME and SPARC systems.

dSPACE GmbH 823
Paderborn, West Germany,
will exhibit development system software and DSP hardware for implementation of high-speed multivariable controllers, hardware-in-the-loop simulation, and signal processing systems.

BOOTH

DYNAIR Electronics Inc. 612
San Diego, CA,
specializes in low-cost analog and digital video and audio routing and distribution system solutions utilizing fiber optic and coaxial cable.

Earth Observing System 830
(Goddard Space Flight Center)
This display will spotlight technologies for EOS, a remote sensing mission to study the oceans, land masses, and atmosphere; their interactions; and how the Earth's system is changing.

Eastman Kodak Company 520,522
Rochester, NY,
will display technologies and capabilities key to several NASA programs, including the Great Observatories, the Space Exploration Initiative and Mission to Planet Earth. Included will be a demonstration of Kodak's new high-resolution infrared imaging system.

Extrudehone Corp. 726
Irwin, PA,
will display its line of capacitance-based surface roughness measuring instruments. A recent addition to the line utilizes Fringe Field capacitance to measure a surface's profile.

FLIR Systems Inc. 222, 224
Industrial Products Div.
Portland, OR,
will exhibit infrared thermal video systems used to determine thermal profiles in a number of industrial and medical applications.

GeoSpectra Corp. 614
Ann Arbor, MI
A leader in Landsat and Spot satellite image processing software and services, GeoSpectra will exhibit ATOM (Automatic Topographic Mapper) software and the SenPLAT sensor platform attitude measurement device.

Geotronics of North America 525,527
Novato, CA,
will display a total control system which includes an electronic distance meter, proportional-internal-differential controller, and a software program that positions any linear moving object.

Goddard Space Flight Center 412
Greenbelt, MD
See page 14.

Grumman Data Systems 218,220
Bethpage, NY,
will display its capabilities in large-scale computer systems integration. Among its many projects, Grumman is supplying NASA's Johnson Space Center with a supercomputer-based system for its engineering computing facility.

Hallcrest Products Inc. 629
Glenview, IL,
will showcase its range of temperature- and shear-sensitive liquid crystal products for use in engineering and aerospace research, particularly in heat transfer and flow visualization studies.

Harris Semiconductor 612
Military and Aerospace Div.
Melbourne, FL

Heimann Systems 612
Iselin, NJ
Literature features Heimann's line of infrared thermometers and blackbody radiation sources.

Hewlett-Packard Company 506
Rockville, MD,
will exhibit high-performance UNIX workstations, including new RISC and Motorola technology.

BOOTH

High Technology Services Inc. 327
Troy, NY,
will display thermoplastic polyimide resins, powders, and foams used in the aerospace, electronics, and defense industries.

Hitachi Chemical Electro-Products 630
Tucker, GA,
will feature Multiwire, a discrete wiring technology providing superior performance for impedance control, crosstalk management, critical signal lengths, and high packaging densities.

Hitachi Denshi America Ltd. 834,836
Woodbury, NY,
will show the C70-2010R Large Screen Data Display Monitor, a 70" diagonally-measured high-resolution display used by command centers and R&D institutions. It is compatible with virtually any computer resolution and is bright enough to be used in high ambient light.

Hughes Santa Barbara 303
Research Center
Goleta, CA
A leading supplier of space sensor systems, SBRC will exhibit electro-optical technologies for space projects such as NASA's Mission to Planet Earth.

Hyperception 206,208
Dallas, TX,
will show digital signal processing and image signal processing software/hardware, including Hypersignal and Hypersignal-Windows DSP software, and Impro-Lab image processing software.

Idaho National Engineering 515
Laboratory
Idaho Falls, ID,
will display activities INEL conducts with applications to current space programs, including space nuclear power and propulsion, simulation and modeling, ground testing, and engineering.

IDEAS Inc. 325
Columbia, MD,
will feature spaceflight-qualified hardware and space station robotics. The company's electronic assemblies are major parts of the Cosmic Background Explorer, Mars Observer, and many other NASA missions.

Inductron Corp. 517
Hampton Roads, VA,
will demonstrate a portable, low-cost induction bonding system for rapid, reliable joining of plastics, ceramics, and metals. The system is used in the military, aerospace, automotive, medical, and industrial fields for manufacture and repair.

Information Development Inc. 123
Houston, TX,
specializes in technical writing and training in such areas as engineering, manufacturing, medicine, construction, and aerospace, as well as in the administrative side of business. Additional services include graphics, computer-aided design and drafting, and packaging.

Information Handling Services 119
Englewood, CO,
will exhibit databases available on CD-ROM systems for data searching. IHS provides comprehensive collections of technical information to the engineering community.

Intelligent Interfaces Inc. 612
Stone Mountain, GA
A catalog presents products for improving productivity of CAD/CAE/ATE workstations.

BOOTH

International Computers 626
& Telecommunications Inc.,
Rockville, MD
ICT writes technical briefs and creates supporting illustrations published in *NASA Tech Briefs*, and also provides technical services in information management, telecommunications, logistics, engineering, and systems integration.

Jet Propulsion Laboratory 523
Pasadena, CA
See page 14.

Johnson Space Center 516
Houston, TX
See page 14.

JP Technologies 403
Upland, CA,
manufactures foil and silicon sensors for measurement of strain, temperature, and electromagnetic radiation.

JR^3 Inc. 424,426
Woodland, CA,
will demonstrate its family of intelligent six-degree-of-freedom force/movement sensors.

Kennedy Space Center 619
Florida
See page 14.

Langley Research Center 315
Hampton, VA
See page 14.

Lewis Research Center 312
Cleveland, OH
See page 14.

Lucas Datalab 402
Severna Park, MD,
will exhibit transient waveform recorders which can record over 200 channels of data at sample rates up to 100 mHz per channel.

Marshall Space Flight Center 417
Huntsville, AL
See page 14.

Martin Marietta Astronautics Group 414
Denver, CO
This exhibit will feature the Flight Telerobotic Servicer (FTS), a telerobotic system being developed for use on space station Freedom.

Martin Marietta 416
Manned Space Systems
New Orleans, LA,
will spotlight potential commercial applications of NASA/Martin Marietta technologies developed for space projects.

Mechanical Technology Inc. 502,600
Latham, NY,
will exhibit external-combustion Stirling engine technology. Under development for NASA, the free-piston Stirling engine is focused on the power requirements of lunar base and planetary exploration vehicles. The multifuel, kinematic Stirling has been developed as an automotive engine which is inherently quieter, cleaner, and more fuel-efficient than a spark ignition engine.

MGA Inc. 723
Concord, MA,
specializes in the commercialization and distribution of expert-authored technical software for the scientific and engineering communities in such technical disciplines as simulation, control design, project management, and digital signal processing.

BOOTH

Micro Industries Corp. 323
Westerville, OH,
will exhibit the MIB II 386/SYS system for developing and testing application software for Multibus II board products. It simplifies the development of Multibus II hardware based on Intel's 80186, 80386, and 80960 microprocessors.

Micro Surface Corp. 625
Morris, IL,
provides coatings for harsh environments where temperature, vacuum, and normal wet lubes cannot be used. Coatings are available for applications with mechanical parts, composite plastics, and powder metal.

Mikron Instruments Company Inc. 214
Wyckoff, NJ,
will display the M668 Infraducer, an infrared fiber optic thermometer which allows selection of temperature range and on-site output signals and eliminates water-cooled systems in the glass, metals, and refractory industries.

Mississippi Department of 740
Economic Development
Jackson, MS
Mississippi's investment in the identification and development of innovative technologies has created a beneficial climate for economic development.

Motorola Inc. Government Electronics Group 300
Scottsdale, AZ,
will discuss the division's space system capabilities, including communications systems, radar systems, and electronic equipment used to track satellites, aircraft, and missiles.

NASA Centers for the 826,828
Commercial Development of Space

NASA Small Business Innovation Research (SBIR) 610
Washington, DC,
will showcase products and processes in diverse technologies developed by small firms through participation in the SBIR program.

NASA Tech Briefs 827
New York, NY

NASA Technology Utilization Program 115,117
Washington, DC

National Standards Association 415
Gaithersburg, MD,
will show CD-ROM products, including Specmaster, a full-text, DOD-listed standards and specifications system, and Partsmaster, a logistics support system.

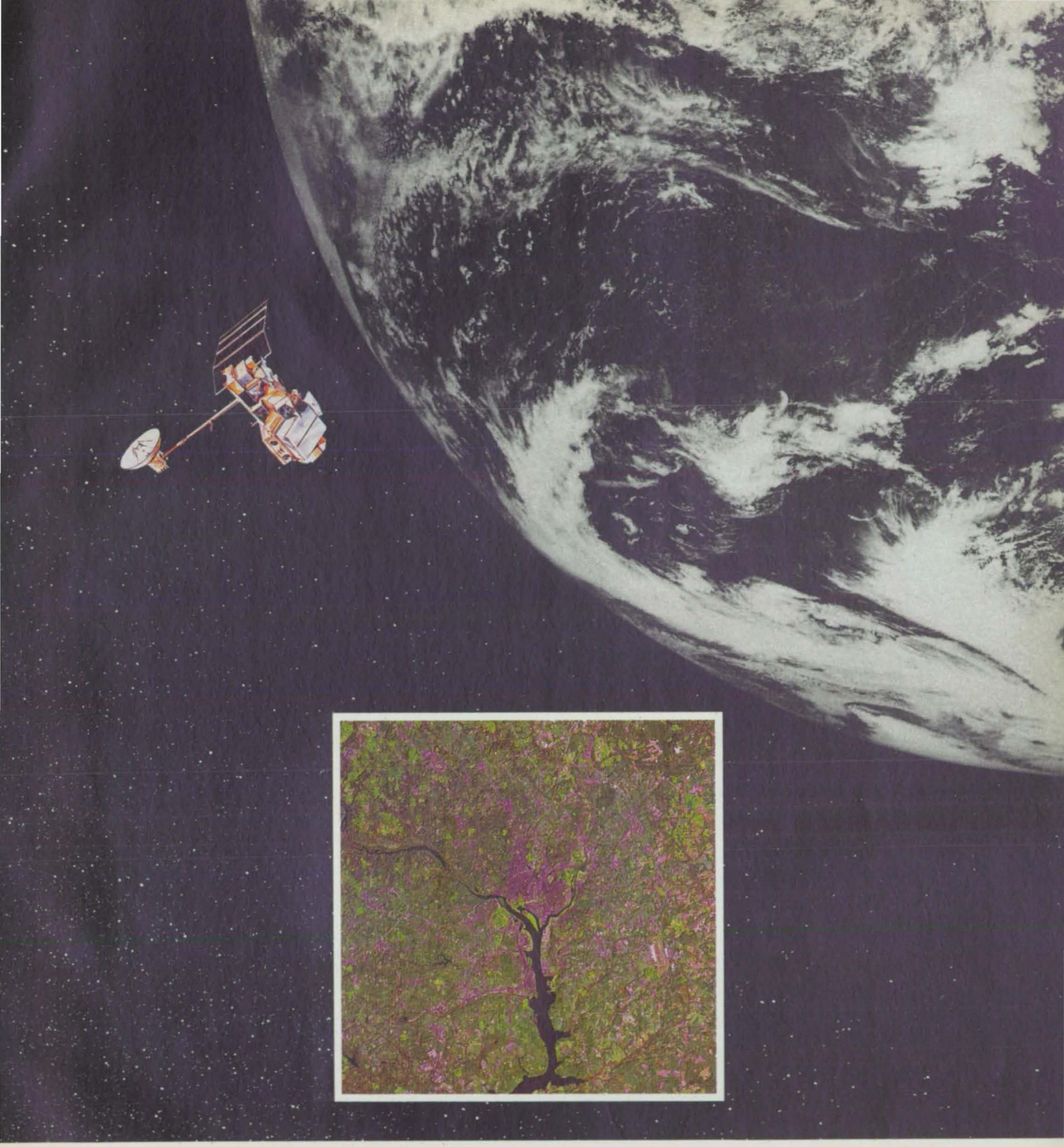
NERAC Inc. 505
Tolland, CT,
will display its Expert Match Database, developed by NERAC to track current expertise within the federal laboratories.

New York State Science and Technology Foundation 105
Albany, NY,
will feature information about the Centers for Advanced Technology, Cornell Supercomputer, venture capital, grant programs, technology development organizations, and products.

NIAC/Applied Research 432
Pittsburgh, PA
NIAC provides a wide range of technology management services, including information retrieval, technology assessment, database development, and marketing research. It works closely and will share the exhibit booth with the University of Pittsburgh's Applied Research Center, the Center for Hazardous Materials Research, the National Environmental Technology Application Center, and Metalworking Technology Inc.

Nicolet Instruments Corp. 405
Madison, WI,
will highlight four new models of high-resolution digital oscilloscopes: the Nicolet 410, 410E, 420, and 420E. With 12-bit digitizers operating at 1 megasample per second and the longest memory available, these models are suited for material testing, electrical power analysis, electro-mechanical testing, and chemical or physiological measurements.

Novespace 632
Paris, France,
will present technologies for sale or license from French high-tech companies.



Over 200 Years In Space

The Landsat 5 spacecraft shown carries two Santa Barbara Research Center multispectral space sensors: the Multi-Spectral Scanner (MSS) and the Thematic Mapper (TM). SBRC designed and built all the Landsat scanning sensors launched since 1972, as well as a wide range of meteorological and planetary exploration sensors since 1966.

SBRC has established world leadership in multispectral space sensor technology by successfully designing and fabricating 65 electro-optical instruments of 19 different designs with a combined operating life now exceeding 225 years.

HUGHES

SANTA BARBARA RESEARCH CENTER
a subsidiary

SBRC : WORLD LEADER IN MULTISPECTRAL SPACE SENSOR TECHNOLOGY

SEE US AT BOOTH 303/TECHNOLOGY 2000

Circle Reader Action No. 414

BOOTH

Numerical Algorithms Group **529**
Downers Grove, IL,
will exhibit scientific and engineering software for mathematically-oriented projects. The software is primarily reusable subroutine packages for FORTRAN, ADA, and C languages.

NYMA Inc. 605
Greenbelt, MD
NYMA is an SBA-Certified 8(a) systems engineering, integration, software, and computer products supplier and supports a number of NASA field centers.

Oak Ridge National Laboratory 316,318
Knoxville, TN

OCA Applied Optics 519
Garden Grove, CA,
will show infrared and visible subsystems developed for imaging and remote sensing systems, as well as a space-qualified laser transceiver.

OCA Lambda/Ten Optics 521
Westford, MA,
will display collimators and telescopes for remote sensing and high-accuracy mirrors for long-range communications.

Olympus Corp. IFD **621**
Lake Success, NY,
will exhibit industrial fiber optics, borescopes, fiberscopes, light sources, and high-pressure and high-temperature scopes.

Optical Coating Laboratory Inc. 404
Santa Rosa, CA,
will display MetaMode™, an advanced dielectric sputtering technology designed to produce high-density, multilayer thin films for a variety of uses.

Pacific Precision Laboratories Inc. 212
Chatsworth, CA,
will feature submicron systems, specials, and stages for lasers, optics, semiconductors, and disk drive measurement, inspection, and test.

PanTech Inc. 329,330
Springfield, VA,
will display for Knurr/USA Inc. a modular enclosure system for Earth stations such as the Hubble Telescope control center at NASA Goddard. PanTech will also exhibit high-resolution displays from Intecolor and ITT Powersystem UPS, and portable Earth stations from EDAK Inc.

Patton & Patton Software Corp. 125
Morgan Hill, CA,
will shows Flow Charting 3 software for IBM and compatible computers, designed for auditors, quality engineers, and programmers to speed the process of developing and updating flowcharts.

PHD Technologies Inc. 724
Pittsburgh, PA
Quest Systems Inc.
Bloomfield, CT,
will feature robots for application in nuclear and other hazardous environments, and technology used to create a four-legged walking robot.

PMS Electro-Optics 401
Boulder, CO,
will exhibit tunable Helium-Neon lasers, including orange (612nm), yellow (594nm) and green (543nm).

Primavera Systems Inc. **423,425**
Bala Cynwyd, PA,
will display its full line of project management software, including Primavera Project Planner (P3), which integrates project scheduling, resource allocation and leveling, and cost control.

BOOTH

Pyraponic Industries Inc. **831**
San Diego, CA,
will demonstrate its Phototron® plant growth chamber, scheduled for further evaluation on space station Freedom as a testbed for biological water/air reclamation and recycling.

Qutron 617
Allendale, NJ,
will exhibit a scan converter, complete with zoom and positioning functions, for the production of TV/video images from virtually any 15 to 128 kHz scan rate RGB analog source.

Ramtek Corp. 304,306
San Jose, CA,
will demonstrate Millennium, a high-resolution subsystem designed to accelerate the processing and visual display of technical and scientific data. It is used in image processing applications including geographical analysis for the petrochemical industry, geographical information systems, and the processing of satellite data for weather prediction.

Raytheon Company 530
Quincy, MA,
will exhibit custom hybrids and high-density power supplies for space applications.

RGB Spectrum **113**
Berkeley, CA,
will feature the latest model of the RGB/View Video Windowing System, which displays live television or other video on a high-resolution computer monitor. The video is shown in real time in a window that can be positioned, scaled, clipped, and overlaid with computer graphics.

R G Hansen & Associates **314**
Santa Barbara, CA,
will display laboratory cryogenic systems and components, including an electro-optic cryogenic test chamber that can handle solid state devices from 100-pin devices to 28-pin clamps and 24-pin tubs.

Ribbon Technology Corp. 407
Gahanna, OH,
will present "Melt Overflow," a system for rapid solidification of metal alloys. It can produce products in the form of fiber, particulate, and strip or sheet.

Rockwell International 508,510,512,514
Space Systems Div.
Downey, CA

Rotating Memory Services 226
Campbell, CA,
repairs or exchanges disk drives. Specializing in 5.25" and 3.5" Winchester disk drives, RMS manufactures Securestor removable hard disk drives with capacities from 20 to over 400 mb.

Satellite Data Systems Inc. 614
Cleveland, MN,
will exhibit Electro-Services® WeatherFax, a system to acquire, display, and enhance weather satellite images using a personal computer.

Scientific & Technical 112,114,211,213
Information Facility
Technology Utilization Office
Baltimore, MD,
will showcase products created in the last decade which incorporate NASA technology. In addition, a publication describing successful reapplication of aerospace technology will be distributed.

Scientific Measurement Systems Inc. 613
Austin, TX,
will exhibit industrial computed tomography systems for non-destructive inspection of aerospace and space components. This technology has been used to inspect materials ranging from metals and ceramics to plastics and composites.

BOOTH

Sensor Developments Inc. 627
Lake Orion, MI,
will feature custom and standard force and torque sensors, and instrumentation modules.

Sensor Frame Corp. 616
Pittsburgh, PA,
will display the Sensor Frame™, an optical gesture sensing device which allows the use of natural hand motions to interact with a computer, and the VideoHarp™, a new type of electronic musical instrument based on the same technology.

Silicon Graphics Computer Systems 317,319
Bethesda, MD,
will demonstrate binary compatible computer systems with applications in advanced visualization, graphics, and server technology.

Sony Corp. of America 219
Business and Professional Group
Lanham, MD

Space News 513
Springfield, VA,
is a weekly newspaper devoted to the politics and business of space.

Spectrum Manufacturing Inc. **305**
Wheeling, IL,
will feature advanced machining technology for the aerospace industry, including advanced laser cutting capabilities.

Stennis Space Center 742
Mississippi
See page 14.

Stephens Analytical Inc. 411
Champlain, NY,
will demonstrate the MCM moisture analyzers, which offer rapid response, repeatability, accuracy, freedom from drift, and contamination resistance.

Sterling Software 509
Palo Alto, CA,
will exhibit an integrated visualization package, SSV, for scientific or engineering grid-oriented data. It provides full-color 3D viewing, rendering, shading, function mapping, animation, recording to videotape, and specialized computational support.

Structural Research & Analysis **210**
Santa Monica, CA,
will display COSMOS/M, a finite element package consisting of a preprocessor, a mesh and model generator, a postprocessor, and color graphics. The program performs linear and nonlinear static, dynamic, buckling, design optimization, thermal, fluid, and electromagnetic analyses.

Sun Microsystems 730,732
Mountain View, CA,
will demonstrate their distributed computing, high-performance workstations featuring software for government applications.

Superior Products International Inc. 733
Salina, KS,
will exhibit SUPER THERM, an insulation coating using three types of ceramics in a mixture of acrylics and urethanes.

Symbolics Inc. 609
Burlington, MA,
will display MACSYMA® symbolic math software, which tackles mathematical applications in calculus, trigonometry, and any other branch of higher mathematics. It provides 2D and 3D graphics and converts equations into FORTRAN or C.

Systems Research and Applications Corp. — BOOTH 835
Arlington, VA,
will exhibit advanced software engineering technology, including intelligent interface access to remote databases and intelligent document management systems based on NASA's 4.3 standard.

Talarian Corp. — 507
Greenbelt, MD,
will display a group of software products used to build real-time monitoring and control applications. It also will demonstrate a monitoring application developed for the Hubble Space Telescope.

Technical Insights Inc. — 612
Fort Lee, NJ,
will present literature describing a weekly service that offers clients information on current research and development, concentrating on significant developments that will be of value to a company's bottom line.

Technology Transfer Society — 618
Indianapolis, IN,
will display publications on the subject of technology transfer and discuss membership benefits and society activities.

Tennessee Technology Foundation, Knoxville, TN, — 320,322,324,326
will spotlight Tennessee technology-based initiatives including the Oak Ridge-Knoxville Technology Corridor, the Tennessee Valley Aerospace Region, Nashville high technology initiatives, and Chattanooga's Partners for Economic Progress.

Textron Specialty Materials — BOOTH 406,408
Lowell, MA,
will display composite materials including boron and carbon fibers, silicon carbide reinforced aluminum, titanium and ceramics, and carbon/carbon composites, as well as fire protection material.

Thermion Inc. — 607
Upper Saddle River, NJ,
will exhibit aircraft anti-ice systems, conductive composites, and No Fire® intumescent coatings.

Thermo Electron Corp. — 612
Tecomet Div., Wilmington, MA,
will present literature about its metalworking services used for fabricating highly complex machined components. Its capabilities include CNC machining, diamond turning, photo etching, electron beam welding, and precise forging.

Tiodize Company Inc. — **608**
Huntington Beach, CA,
will exhibit all-graphite composite aerospace fastening products, self-lubricating graphite composites, and advanced coatings.

TransEra — **612**
Provo, UT,
will offer literature about HTBasic, which allows users to port HP Basic programs from HP Basic workstations to an IBM-compatible PC.

TriMetrix Corp. — 612
Seattle, WA
Company literature will describe how the Axum technical graphics and data analysis package can be used for advanced data analysis and for producing ultra-high-resolution publication-quality graphs.

TRW Inc. — BOOTH **118,217**
Redondo Beach, CA,
will exhibit "Mission to Planet Earth and Beyond," featuring high-technology thrusters, "Smart Strut" precision control of agile spacecraft, lunar base technology, a Mars lander, cryogenic coolers, EOS technology, and microelectronics.

Turbomixer Corp. — 103
Newark, DE,
will display its rotating coil technology, a recently discovered principle of fluid dynamics which is being harnessed in various coil configurations to improve mixing, blending, dispersing, emulsifying, aerating and gas-into-liquid dissolving for research, production, and environmental purposes.

United States Air Force — 725,727,729

University of Dayton Research Institute — 321
Dayton, OH
UDRI focuses on the advanced research and development needs of the government and private sector in such areas as thermal energy storage materials, software for analysis of complex structures, high-temperature structural composites, and novel aircraft propulsion systems.

University of Florida — 308
Department of Materials Science and Engineering
Gainesville, FL
University of Florida researchers use microwave energy to process a variety of materials, including superconductors, composites, and electro-optics. Experiments have shown that microwave processing can produce more homogeneous microstructures using less time and lower temperatures than with conventional methods.

BOOTH

United Technologies (USBI) 413
Kennedy Space Center, FL,
will display graphics depicting its current role as prime contractor to NASA for the assembly and refurbishment of the space shuttle's solid rocket boosters, as well as its involvement in Shuttle-C activities.

Valcor Engineering Corp. 310
Springfield, NJ,
will showcase a variety of solenoid-operated valves including vacuum, latching, check, and excess flow check valves, relief valves-pressure regulators, and related pneumatic subsystems.

Vermont Research Corp. 400
North Springfield, VT,
will exhibit solid-state disk systems with interfaces to SCSI, SMD, ESMD, and 160 other emulations.

Vetronix Research Corp. 433
Troy, MI,
will display the Multiplexed Electrical Power Control and Management system, developed to handle the U.S. Army's power and data distribution in the M1A2 main battle tank.

Virginia's Center for Innovative Technology 418
Herndon, VA,
will provide information on Virginia's space industry development and technology transfer programs, initiatives, and products.

VI Corp. 422
Northampton, MA
VI markets DataViews, tools for data management and display in the development of dynamic graphical user interfaces. The company will display DataViews Release 8.0, which includes support for Motif widgets, new dynamics and graph types, and reduced need for programming.

Walcoff & Associates Inc. 619
Alexandria, VA,
will provide information on its technical management consulting and communication services to both government and private sector clients.

Water Filter Company of America 616
National City, CA,
will display a water treatment unit for home use based on NASA technology.

Wave Shield Technology 420
Lincoln, NE,
will exhibit electromagnetic shielded composites for the electronics and aerospace industries.

Wisconsin Center for Space Automation and Robotics 738
Madison, WI
WCSAR will display a compliant 4-degree-of-freedom fingertip force sensor for robotic applications, a Telerobotic Performance Analysis System (TPAS), a unique water and nutrient delivery system for plants, an LED lighting system for plants, and concepts for an automated lunar mining device for extracting gases from the lunar soil.

W L Gore & Associates 307
Newark, DE,
will display Gore microwave coaxial assemblies and Gore-Shield EMI gasketing materials.

Wolfram Research Inc. 503
Champaign, IL,
will showcase Mathematica, a general system for numerical, symbolic, and graphic computations, which can be used as an interactive calculation tool and as a programming language. Its numerical capabilities include arbitrary precision arithmetic and matrix manipulation.

Xybion Electronic Systems Corp. 421
San Diego, CA
Xybion manufactures mechanically-shuttered and electronically-gated video cameras for capturing dynamic events; solid-state low-light-level video cameras; and multispectral video cameras for remote sensing and other diagnostic measurement applications.

Zircar Products Inc. 624
Florida, NY,
will exhibit high-temperature fibrous ceramic thermal, electrical, and structural insulation products. Fiber types include zirconia, alumina, alumina-silica, and other refractory oxide composites.

For a final list of exhibitors and booth locations, consult the official TECHNOLOGY 2000 show program distributed on-site in the show registration area.

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 24). NASA's patent-licensing program to encourage commercial development is described on page 24.

Improved "Smart" Robot Hand

A developmental "smart" robot hand features a high-speed electronic data formatter and synchronizer and a high-speed bidirectional optical-fiber link for the transmission of data to and from the host computer. The rate of transmission of data to and from the hand is about 100 times that of previous versions.
(See page 38)

Fast Feature-Recognizing Optoelectronic System

A proposed optoelectronic system would recognize features or classify images by processing the outputs of photosensors rapidly through circuits developed in research on neural networks. Potential applications include robotic vision systems and pattern recognition.
(See page 42)

Zoom Vision System for Robotic Welding

A rugged zoom lens subsystem proposed for use in the along-the-torch vision system of a robotic welder would enable the system to adapt to gas cups of different lengths, electrodes of different protrusions, and/or different distances between the end of the electrode and the workpiece.
(See page 82)

Segmented Coil Fails in Steps

An electromagnetic coil degrades in steps when faults occur. Coils of this type can be used to control valves in such critical applications as the cooling systems of power generators and chemical process equipment, particularly where flammable fluids are handled.
(See page 36)

Adjustable Induction-Heating Coil

An induction-heating work coil features three segments that can be adjusted independently to obtain the desired distribution of temperature. Successful results were reported from both a 5-kW radio-frequency and a 50-kW audio-frequency induction heaters.
(See page 50)

Making Lightweight Structures by Vapor Deposition

A technique has been developed for the fabrication of strong lightweight structures of silicon carbide or other materials by any of several deposition processes. The structures can be made in complicated shapes, which could lead to new products in optical, automotive, and aerospace fields.
(See page 81)

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low-and no-cost services provided by NASA's Technology Utilization (TU) Network. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by the TU Network as a whole. In fact, when all of the components of NASA's Technology Utilization Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

We've outlined below NASA's TU Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered by NASA's Technology Utilization Network.

How You Can Utilize **NASA's Industrial Applications Centers**—A nationwide network offering a broad range of technical services, including computerized access to over 100 million documents worldwide.

You can contact NASA's network of Industrial Applications Centers (IACs) for assistance in solving a specific technical problem or meeting your information needs. The "user friendly" IACs are staffed by technology transfer experts who provide computerized information retrieval from one of the world's largest banks of technical data. Nearly 500 computerized data bases, ranging from NASA's own data base to Chemical Abstracts and INSPEC, are accessible through the ten IACs located throughout the nation. The IACs also offer technical consultation services and/or linkage with other experts in the field. You can obtain more information about these services by calling or writing the nearest IAC. User fees are charged for IAC information services.

Aerospace Research Center (ARAC)
Indianapolis Center for Advanced Research
611 N. Capitol Avenue
Indianapolis, IN 46204
Dr. F. Timothy Janis, Director
(317) 262-5036

Central Industrial Applications Center/NASA (CIAC)
Rural Enterprises, Inc.
P.O. Box 1335
Durant, OK 74702
Dr. Dickie Deel, Director
(405) 924-5094
(800) 658-2823 (toll-free U.S.)

Science and Technology Research Center (STRC)
Post Office Box 12235
Research Triangle Park, NC 27709-2235
H.L. (Lynn) Reese, Director
(919) 549-0671

NASA Industrial Applications Ctr. 823 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
Lani Hummel
Acting Director
(412) 648-7000

Southern Technology Applications Center (STAC)
Box 24
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Alachua, FL 32615
J. Ronald Thornton, Director
(904) 462-3913
(800) 354-4832 (FL only)
(800) 225-0308 (toll-free US)

NASA/UK Technology Applications Program
University of Kentucky
109 Kinkead Hall
Lexington, KY 40506-0057
William R. Strong, Director
(606) 257-6322

NERAC, Inc.
One Technology Drive
Tolland, CT 06084
Dr. Daniel U. Wilde, President
(203) 872-7000

Technology Application Center (TAC)
University of New Mexico
Albuquerque, NM 87131
Dr. Stanley A. Morain, Director
(505) 277-3622

NASA Industrial Applications Center
University of Southern California
Research Annex
3716 South Hope Street
Los Angeles, CA 90007-4344
Robert Stark, Director
(213) 743-6132
(800) 642-2872 (CA only)
(800) 872-7477 (toll-free US)

NASA/SU Industrial Applications Center
Southern University Department of Computer Science
P.O. Box 9737
Baton Rouge, LA 70813-9737
Dr. John Hubbell, Director
(504) 771-6272
(504) 771-4950

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709.** ***Doris Rouse, Director,*** **(919) 541-6980**

How You Can Access Technology Transfer Services At NASA Field Centers:
Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in NASA Tech Briefs, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

Ames Research Ctr.
Technology Utilization Officer: Laurance Milov
Mail Code 223-3
Moffet Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

Lewis Research Center
Technology Utilization Officer: Anthony F. Ratajczak
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-2225
Patent Counsel:
Gene E. Shook
Mail Code LE-LAW
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

John C. Stennis Space Center
Technology Utilization Officer: Richard A. Galle (acting)
Code HA-32
Stennis Space Center, MS 39529
(601) 688-1929

John F. Kennedy Space Center
Technology Utilization Officer: Thomas M. Hammond
Mail Stop PT-PMO-A
Kennedy Space Center, FL 32899
(407) 867-3017
Patent Counsel:
James D. Harrell
Mail Code PT-PAT
Kennedy Space Center, FL 32899
(407) 867-2544

Langley Research Ctr.
Technology Utilization Officer: John Samos
Mail Stop 139A
Hampton, VA 23665
(804) 864-2484
Patent Counsel:
George F. Helfrich
Mail Code 279
Hampton, VA 23665
(804) 864-3523

Goddard Space Flight Center
Technology Utilization Officer: Donald S. Friedman
Mail Code 702.1
Greenbelt, MD 20771
(301) 286-6242
Patent Counsel:
R. Dennis Marchant
Mail Code 204
Greenbelt, MD 20771
(301) 286-7351

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Arif Husain
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel:
Thomas H. Jones
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-5179
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

George C. Marshall Space Flight Center
Technology Utilization Officer: Ismail Akbay
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
Fax (205) 544-3151
Patent Counsel:
Bill Sheehan
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0021

Lyndon B. Johnson Space Center
Technology Utilization Officer: Dean C. Glenn
Mail Code IC-4
Houston, TX 77058
(713) 483-3809
Patent Counsel:
Edward K. Fein
Mail Code AL3
Houston, TX 77058
(713) 483-4871

NASA Headquarters
Technology Utilization Officer: Leonard A. Ault
Code CU
Washington, DC 20546
(202) 557-5598
Assistant General Counsel for Patent Matters: Robert F. Kempf, Code GP
Washington, DC 20546
(202) 453-2424

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If You Have a Question..**NASA Scientific & Technical Information Facility** can answer questions about NASA's Technology Utilization Network and its services and documents. The STI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Scientific and Technical Information Facility,** Technology Utilization Office, P.O. Box 8757, Baltimore, MD 21240-0757. *Walter M. Heiland, Manager,* (301) 859-5300, Ext. 242,243

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External Peltier Cooler for Low-Noise Amplifier

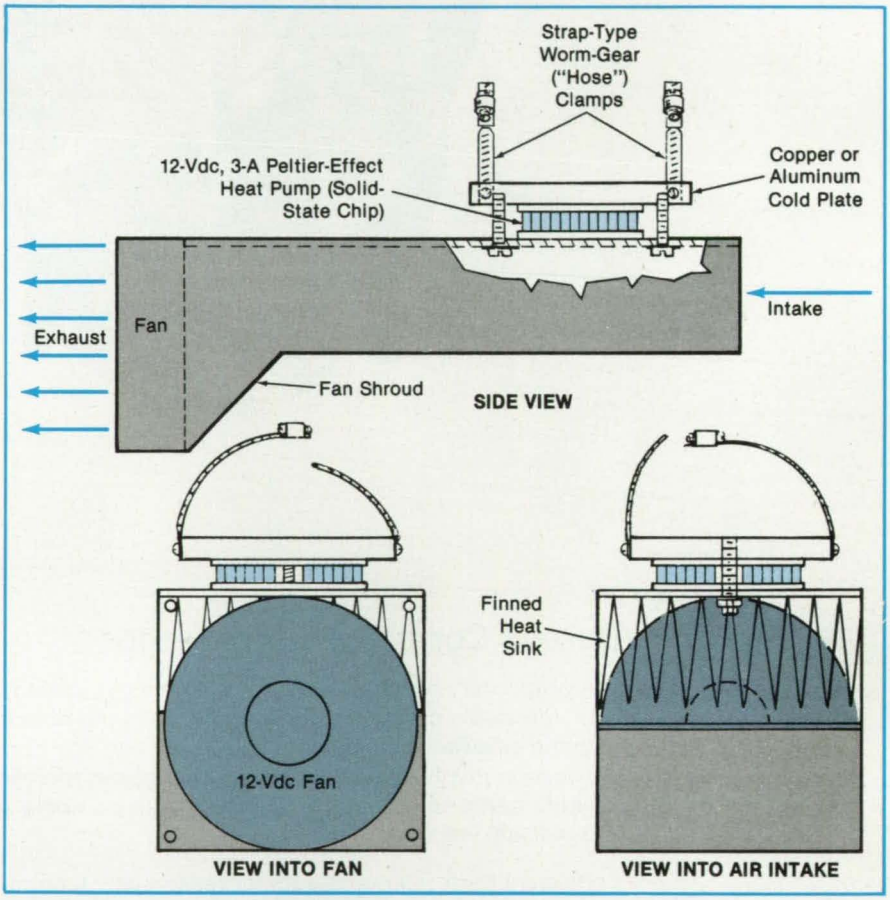
An inexpensive module could be retrofitted to an existing amplifier.

Lyndon B. Johnson Space Center, Houston, Texas

An inexpensive Peltier-effect cooling module made of a few commercially available parts could be used to reduce thermal noise in a microwave amplifier. The module can be retrofitted to almost any microwave low-noise amplifier or receiver preamplifier used in communication, telemetry, or radar. Previously, to take advantage of cooling by the Peltier effect, it was necessary to replace the entire amplifier by one that contains a built-in Peltier cooling chip. Other amplifiers have been cooled by liquid nitrogen, which is expensive.

The retrofitted cooling module (see figure) includes a copper or aluminum cold plate that is held tightly against the unit to be cooled by strap-type worm-gear clamps (known popularly as "hose clamps"). The Peltier-effect heat pump transfers heat from the cold plate to a finned heat sink, through which air is drawn by a fan. A silicone heat-transfer grease improves the thermal conductances of the interfaces between the Peltier chip and the cold plate and between the Peltier chip and the finned heat sink. The unit to be cooled, the cold plate, and the exposed sides of the Peltier chip are covered with sprayed foam insulation.

The retrofitted module can reduce the temperature of the cooled amplifier by as much as 50 °C. Under appropriate conditions, this could result in an increase in gain of 2.5 dB and a decrease in noise of 0.25 dB.



The **Peltier-Effect Cooling Module** would be strapped onto the amplifier to be cooled.

This work was done by Terry A. Soper of Lockheed Engineering and Management Services Co. for **Johnson Space Center**. *No further documentation is available. MSC-21422*

Voltage-Boosting Driver for Switching Regulator

A capacitative booster supplies increased turn-on voltage efficiently.

Marshall Space Flight Center, Alabama

A driver circuit assures the availability of the 10- to 15-V gate-to-source voltage needed to turn on the n-channel metal oxide/semiconductor field-effect transistor (MOSFET) that acts as the switch in a switching voltage regulator. The driver includes a voltage-boosting circuit that efficiently provides a gate voltage 10 to 15 V above the supply voltage. The driver contains no exotic parts and does not require an additional power supply.

The driver is an integral part of the switching regulator, and is illustrated schematically in the figure. The driver consists of a NAND gate and a dual voltage booster operating in conjunction with a pulse-width modulator that is also part of the regulator. The driver turns switch M_1 on and off at the pulse rate of 40 kHz (set by the pulse-width modulator). The regulated output voltage is controlled by controlling durations of the pulses and, thereby, of the "on" and "off" periods of the switch. These, in turn, are controlled by the pulse-width modulator, which responds to the feedback voltage signal by adjusting the

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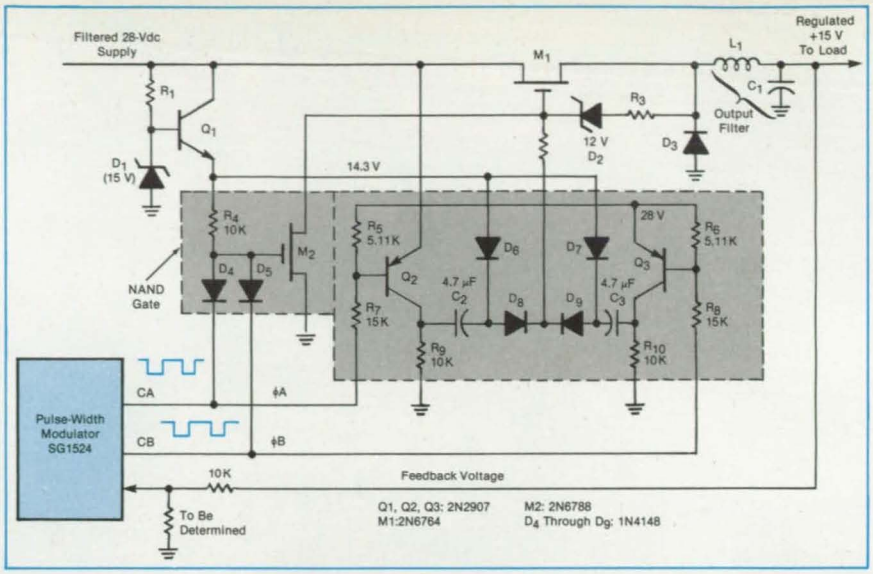
durations and phases of the pulse trains CA and CB that it puts out. When CA and CB are both high, M_1 is held off by the NAND gate. When either CA or CB is low, M_1 is turned on. (Internal logic in the pulse-width modulator prevents both CA and CB from being low at the same time.)

The dual voltage booster is based on the well-known capacitive-voltage-booster principle. Assume, for example, that during the first part of a cycle, CA is high and CB is low. Q_3 is saturated, and its collector is ~0.2 V below the filtered 28-Vdc supply. C_3 was charged to about 13.5 V during the second part of the preceding cycle, causing the anode of D_9 to be ~13.5 V above the collector of Q_3 and enabling the gate of M_1 to be ~12.5 V above the filtered 28-Vdc supply. This voltage is more than enough to keep M_1 switched on (except when the NAND gate keeps it off). During this part of the cycle, C_2 is being charged via D_6 and R_9.

During the second part of the cycle, CA is low and CB is high. Q_2 is saturated and its collector is ~0.2 V below the filtered 28-Vdc supply. The charge accumulated on C_2 during the first part of the cycle is sufficient to keep the gate of M_1 ~12.5 V above the filtered 28-Vdc supply and thus turned on (except when the NAND gate keeps it off). During this part of the cycle, C_3 is being charged via D_7 and R_{10}. During both parts of the cycle, D_2 and R_3 prevent the gate-to-source voltage from exceeding the rated value for M_1 and assure reasonable operation in the event of a small load (even an open circuit).

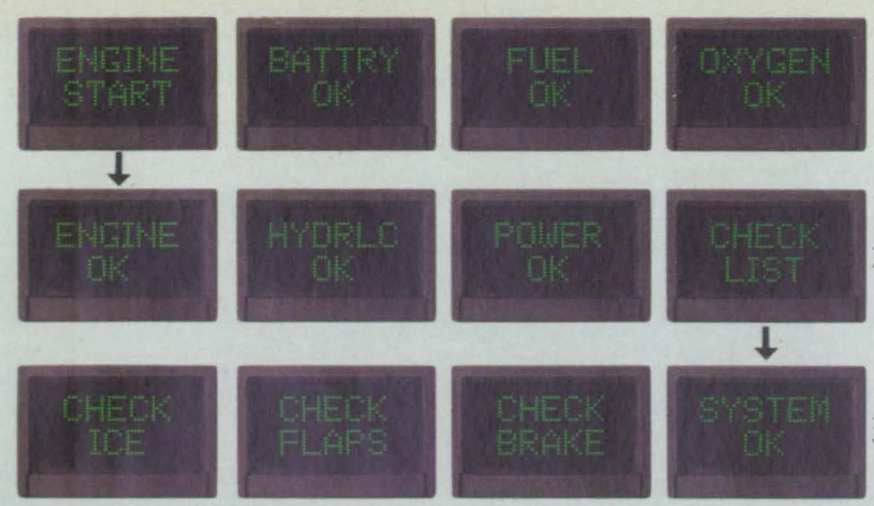


The **Driver Circuit,** consisting of the NAND gate and the dual voltage booster, provides a voltage ~ 12.5 V above the 28-V supply to turn on switching transistor M_1.

The driver can be made of readily available, inexpensive components. It could even be made as an integrated circuit, possibly integrated with the pulse-width modulator, by a process similar to that used to make the pulse-width modulator. It can operate over a wide range of primary supply voltage, pulse rate, and temperature.

This work was done by Ronald C. Trump of Honeywell, Inc., for **Marshall Space Flight Center**. *For further information, Circle 87 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28437.



AN APPLICATIONS EXAMPLE. While the following example is for aircraft, it could apply to any air, land, sea or space system.

SEQUENCE ONE: The four-pushbutton display reads "ENGINE START," "BATTERY OK," "FUEL OK," OXYGEN OK." The operator selects "ENGINE START."

SEQUENCE TWO: The four-pushbutton display now changes to read "ENGINE OK," "HYDRLC OK," "POWER OK," "CHECK LIST." The operator selects "CHECK LIST."

SEQUENCE THREE: The four-pushbutton display now reads "CHECK ICE," "CHECK FLAPS," "CHECK BRAKE," "SYSTEM OK." In this manner, the designer can program in as many sequences as required.

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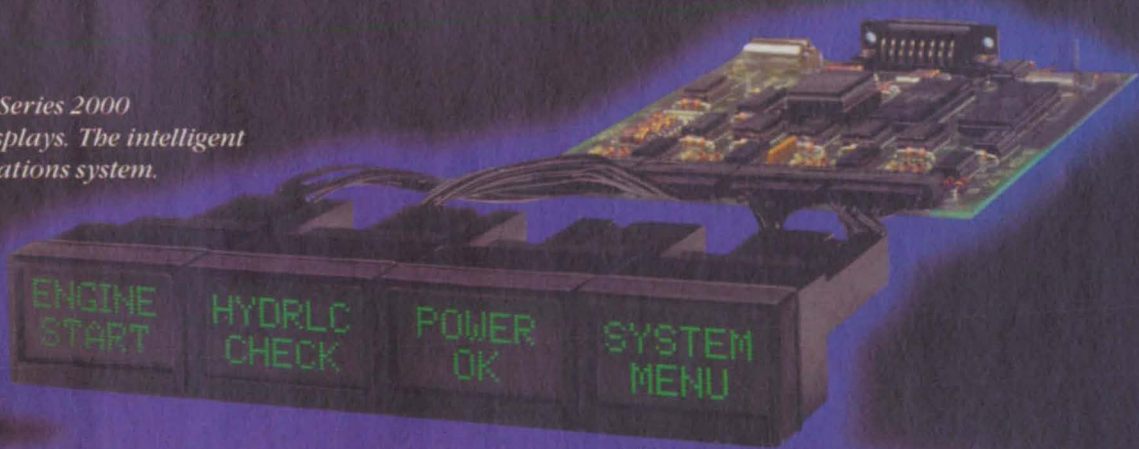


SERIES
VIVISUN 2000™

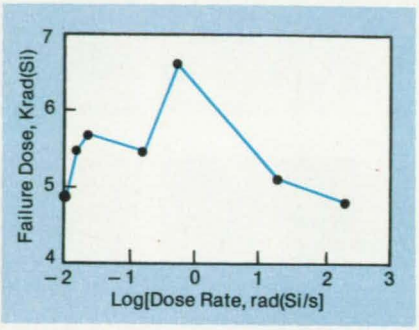
Failures of CMOS Devices at Low Radiation-Dose Rates

The failure dose depends on the dose rate.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method for obtaining approximate failure-versus-dose-rate curves has been derived from experiments on the failures of SGS 4007 complementary metal oxide/semiconductor (CMOS) integrated circuits irradiated by Co^{60} and Cs^{137} radioactive sources. The experiments had focused on the effects of the dose rate on the total failure dose and on the possible existence of a different failure mechanism at low dose rates.

Four SGS 4007 devices were irradiated by Co^{60} at 20 rad(Si)/s, four at 0.50 rad(Si)/s, and three at 0.014 rad(Si)/s. Three devices each were irradiated by Cs^{137} at 0.021 rad(Si)/s and 0.010 rad(Si)/s. The devices were connected to an HP4062C Semiconductor-Parameter Test System, which applied the appropriate biases and measured drain-to-source leakage currents and threshold voltages. For the purpose of this study, failure was deemed to occur when the current or voltage parameter in question exceeded the value specified by the manufacturer or the JPL project requirement.



The **Failure Dose** varies with the dose rate. Note that the failure dose is low at low dose rates, indicating the existence of a low-dose-rate failure mechanism.

The data obtained in these experiments show that the failure dose increases with the dose rate, reaching a peak at a dose rate of ~1 rad(Si)/s, then decreasing, then leveling off above ~200 rad(Si)/s (see figure). The low-dose portion of these data adds to the evidence of a different failure mechanism at low dose rates, and the experimenters recommend that other radiation-effects researchers investigate this phenomenon.

Examination of the plots of these data suggested an economical way to obtain an approximation to the parameter-failure-versus-dose-rate curve and to determine, without having to irradiate the device to failure, that dose rate at which a device would fail before it would fail at any other dose rate. Plotting a parameter (e.g., threshold voltage shift) that decreases with the dose rate indicates clearly the dose rate at which the parameter is most sensitive to radiation and will reach a failure value first. Plotting the reciprocal of an increasing parameter (e.g., the drain-to-source leakage current) versus the dose rate yields a first approximation to the failure curve, even though the total dose is less than the failure dose.

This work was done by Charles A. Goben and William E. Price of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 79 on the TSP Request Card.*

NPO-17868

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INPUT ELECTRICAL CHARACTERISTICS (–55° to +105° unless otherwise noted)			
	Min	Max	Units
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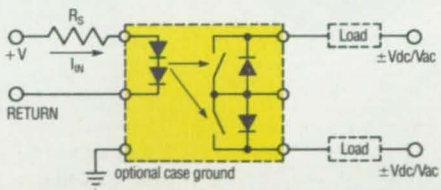
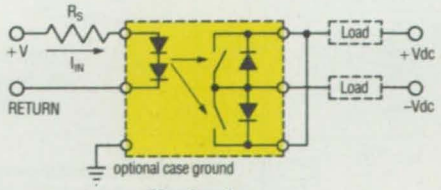
Input Current (Guaranteed On)	10		mA_{DC}
Input Current (Guaranteed Off)		100	μA_{DC}
Input Voltage Drop at (I_{IN}) = 25mA		3.25	V_{DC}

OUTPUT ELECTRICAL CHARACTERISTICS (–55° to +105° unless otherwise noted)				
Part Number	**FB00CD**	**FB00FC**	**FB00KB**	**Units**
Bidirectional Load Current (I_{LOAD})	±1.0	±0.50	±0.25	A_{DC}/A_{PK}
DC Load Current (I_{LOAD})	2.0	1.0	0.5	A_{DC}
Bidirectional Load Voltage (V_{LOAD})	±80	±180	±350	V_{DC}/V_{PK}
DC Load Voltage (V_{LOAD})	80	180	350	V_{DC}
ON-Resistance (R_{ON}) at (I_{LOAD}) max.	0.72	1.8	12.9	Ohms
Turn-On Time (T_{ON})	800	800	500	µs
Turn-Off Time (T_{OFF})	300	600	500	µs

Notes: 1. A series resistor is required to limit continuous input current to 50mA (peak current can be higher).
2. Rated input current is 25mA for all tests.
3. Loads may be connected to any output terminal.
4. ON resistance shown is for the bidirectional configuration. The DC ON resistance is ¼ of these values.



B-directional and ac configuration



DC configuration

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Circle Reader Action No. 537

Multi-Quantum-Well Spatial Light Modulators on Si Substrates

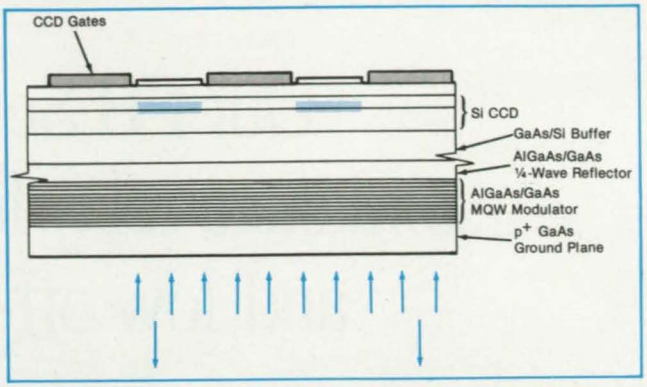
Features would include short response times, high resolution, and low switching energies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed new class of two-dimensional spatial light modulators (SLM's) would be based on the fabrication of multi-quantum-well (MQW) structures (e.g., of AlGaAs and InGaAs) on silicon substrates. SLM's are essential components of optical data processing systems. At present, large-format, high-speed SLM's with low power consumption are not available.

The new concept is to make two-dimensional SLM arrays by taking advantage of the mature technology of silicon charge-coupled devices (CCD's), recent developments in the technology of GaAs/Si interfaces, and continuing research on MQW and other artificial microstructures made of elements from Groups II and V of the periodic table. The following technological advances are particularly relevant to the fabrication of promising new MQW SLM structures:

- The development of high-resistivity silicon and the concomitant ability to make deep depletion layers in silicon,
- The development of advanced etching techniques that make it possible to thin CCD's and CCD-like structures to membranes no thicker than the depletion depth, and
- The development of techniques for the laser-assisted deposition of GaAs on CCD's and other silicon-based multiplexing devices at temperatures low enough to avoid damage to previously deposited metal gates.



This **Multi-Quantum-Well Spatial Light Modulator** would include a Si CDD-like device integrated monolithically with an InGaAs/GaAs-multiple-quantum-well device.

The proposed device, illustrated schematically in the figure, would operate in an absorption/reflection mode using an AlGaAs/GaAs MQW structure. The absorption in the MQW structure is caused by the quantum-confined Stark effect (QCSE). Such MQW structures have been shown to have short response times and low switching energies. In addition to the circuitry for the CCD-like structure with which the MQW portion of the SLM would be integrated, the silicon portion of the monolithic device could also include other signal-processing and/or logic circuitry.

Directly on top of the back surface of the silicon CCD would be a strained-layer superlattice (SLS) buffer layer. This layer lowers the defect density at the interface and enhances the transmission of the modulating electric field to the MQW structure. Between the buffer layer and the MQW stack is an AlGaAs/GaAs ¼-wave reflector that reflects the optical read-beam back through the MQW structure and prevents the beam from entering the silicon CCD.

It would not be necessary to incorporate any of the two-dimensional SLM structure into the MQW layers; instead, the size and resolution of the two-dimensional array would be determined by the stucture of the silicon CCD-like part of the device. The CCD-like array would transfer the charge or voltage pattern to the laterally uniform MQW layers, which would have only a single common electrode.

The SLM's should be optically and electrically addressable. The electrically addressable mode is the more significant capability because of the lack of large-format, high-speed electrically addressable devices.

This work was done by James A. Cutts, Joseph Katz, and Philip J. Dumont of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information , Circle 44 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 24]. Refer to NPO-17651.

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Preventing Simultaneous Conduction in Switching Transistors

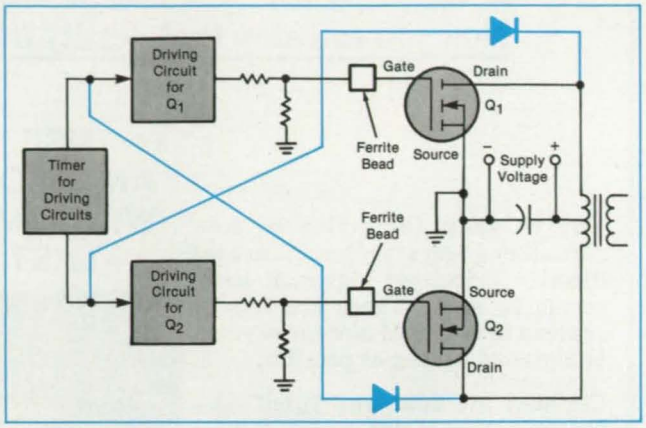
High voltage spikes and electromagnetic interference are suppressed.

NASA's Jet Propulsion Laboratory, Pasadena, California

A power-supply circuit that includes two switching transistors is easily modified to prevent simultaneous conduction by both transistors during the switching intervals. A diode connected between the collector of each transistor and the driving circuit for the opposite transistor suppresses the driving signal to the transistor being turned on until the transistor being turned off has ceased to carry current.

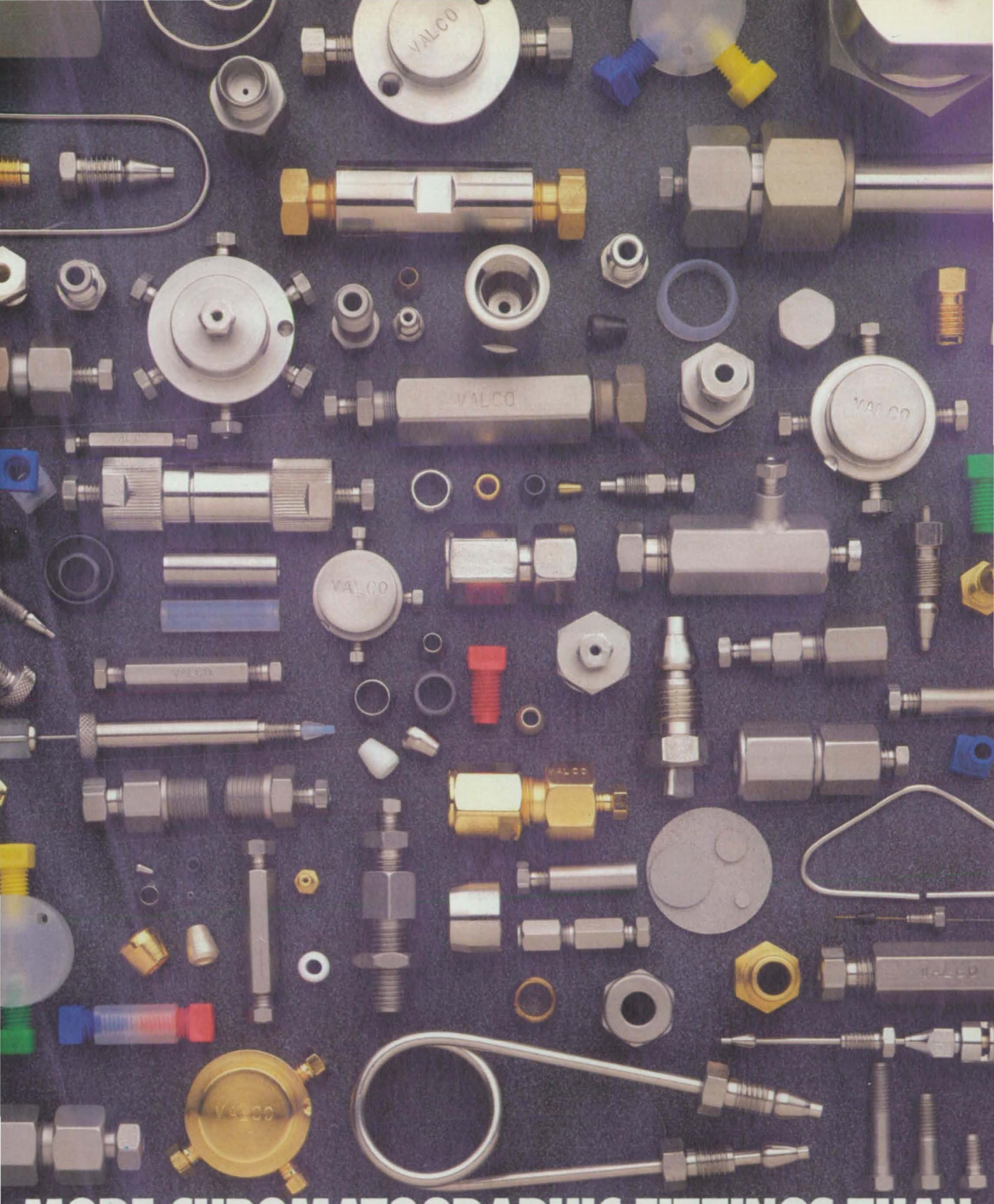
Power transistors turn on much faster than they can turn off. In a driven switching system like a converter or inverter, this effect can cause simultaneous conduction of the switching transistors, which sets up a short circuit across the transformer. When this occurs, the collector current is limited only by the source impedance and the transistor gain. During this simultaneous-high-conductance state, the resulting high current and the transformer leakage inductance combine to generate high voltage spikes that produce large amounts of electromagnetic interference and can easily destroy the transistors.

In the modified circuit (see figure), the cathodes of the diodes are connected to the collectors or drains of the switching transistors. The anode of each diode is cross-strapped to the input of the driving circuit of the opposite transistor. When one of the transistors is conducting, its collector is nearly at ground potential. Through the diode, this places the output of the driving circuit for the other transistor close to ground potential, thus shorting drive current to ground. Some finite time after the drive signal to the conducting transistor is turned off, this transistor stops conducting, the diode becomes back-biased, and the driving circuit of the transistor that was previously not conducting can turn that transistor on.



Two Diodes (shown here in color) are added to this inverter circuit to prevent the application of the driving signal to switching transistor Q_1 until switching Q_2 stops conducting, and vice versa.

This work was done by Colonel William T. McLyman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 55 on the TSP Request Card.*
NPO-17775



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Rain-Blowing Plenum for Antenna Feed Horn

Forced air is partly confined for maximum effectiveness.

NASA's Jet Propulsion Laboratory, Pasadena, California

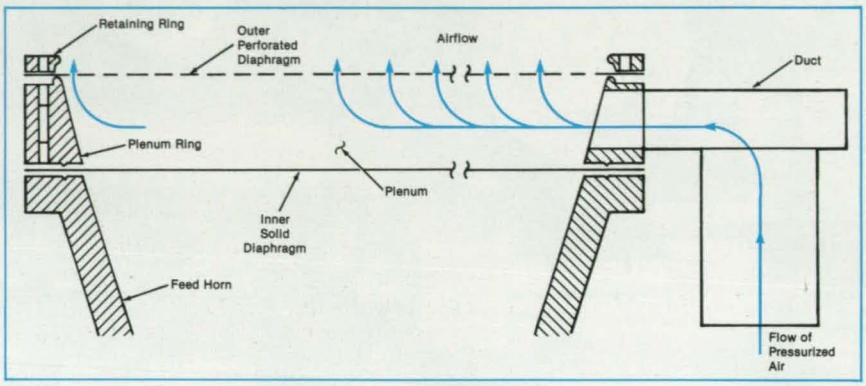
A double-diaphragm radome drives raindrops away from an antenna feed horn. It thus nearly eliminates the increase in noise temperature that occurs when water covers a radome. The double-diaphragm design is particularly useful for X-band and higher frequencies, which are especially susceptible to the effects of water.

A second diaphragm, perforated with holes 0.015 in. (3.8 mm) in diameter on 0.040-in. (1-mm) centers, is placed outside a conventional diaphragm-type radome, forming a plenum with the inner diaphragm. Air forced into the plenum flows out through the holes, floating raindrops away from the outer surface (see figure).

The usual method of clearing rain from a radome is to blow air through a duct, which directs the air across the outer surface. The new double-radome method not only is more effective in clearing the radome but also requires less air. It is therefore suitable for use with large radomes as well as with small ones.

This work was done by Peter S. Hames and Scott R. Stewart of Planning Research Corp. for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 76 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 24].Refer to NPO-17493.



The **Double-Diaphragm Radome** includes a solid diaphragm at the mouth of a feed horn surmounted by a perforated diaphragm. Pressurized air in the plenum between the diaphragms flows out through the perforations.

Segmented Coil Fails in Steps

Insulating barriers prevent propagation of failures.

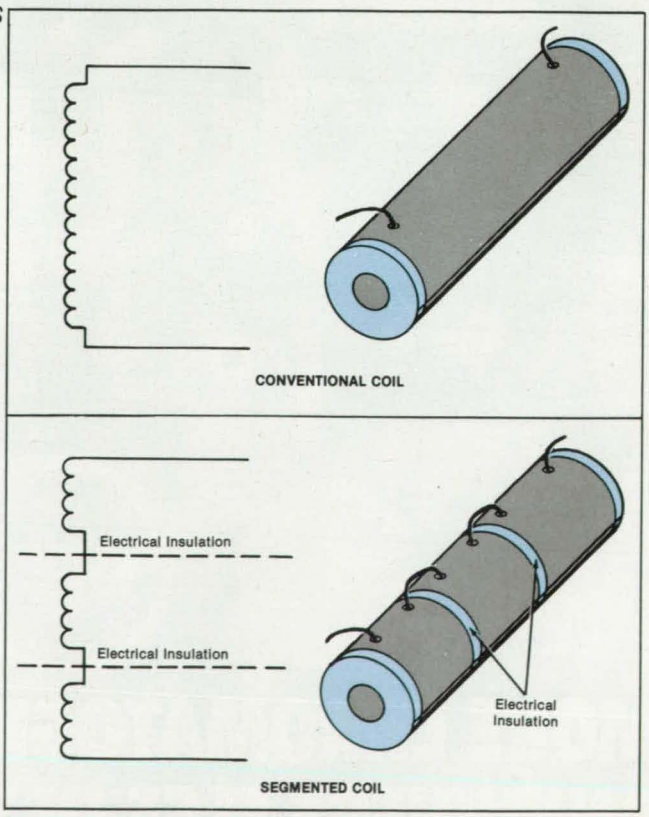
Lyndon B. Johnson Space Center, Houston, Texas

An electromagnetic coil degrades in steps when faults occur — that is, it continues to operate at a reduced level instead of failing catastrophically. In addition, a fault does not damage adjacent components or create a hazard. Coils of this type can be used to control valves in such critical applications as the cooling systems of power generators and chemical process equipment, particularly where flammable liquids or gases are handled. It can also be adapted to the electrical control of motors.

The coil is made in segments connected in series and separated by electrically insulating barriers (see figure). If a short circuit should occur between adjacent wires in a segment, it does not spread beyond that segment. The coil continues to function with the remaining segments intact. The increase in current is restricted to that caused by the decrease in the electrical resistance in the segment that failed. The increase in temperature is not high enough to burn out the coil, damage adjacent components, or cause a fire.

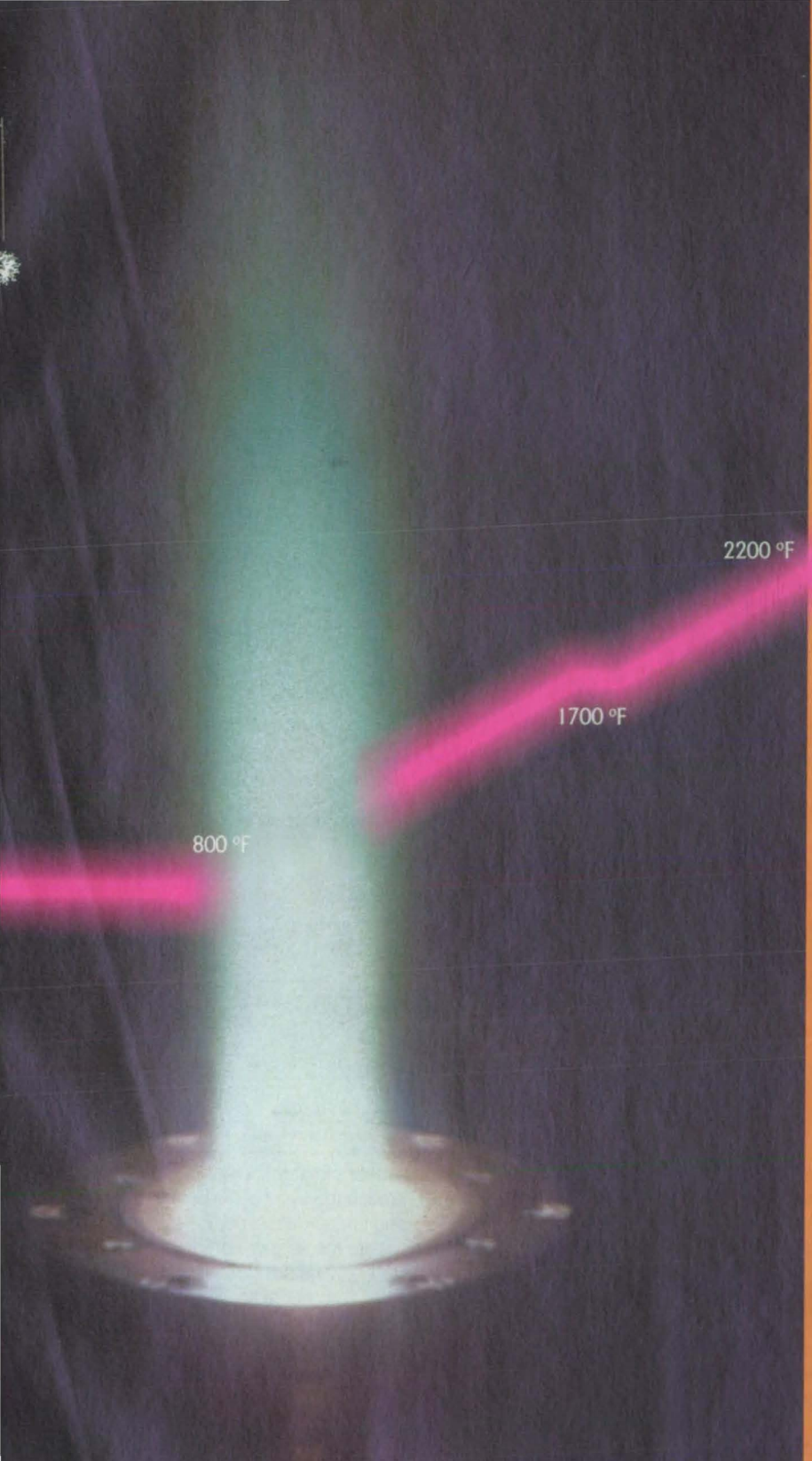
The increase in current and reduction in function caused by failure of a segment can be detected readily. The faulty unit can then be replaced.

A conventional, unsegmented coil, in contrast, relies only on the insulation on the wire for protection against short circuits. If that insulation fails, more and more heat is generated as the failure extends through the entire component.



The **Segmented Coil** keeps a short circuit within a segment. In a conventional coil, however, a short circuit between exposed spots on adjacent wires can result in a rapid increase in temperature, destroying the entire coil.

This work was done by Ronald S. Stedman of Rockwell International Corp. for **Johnson Space Center**. *No further documentation is available.*
MSC-21574



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Circle Reader Action No. 339

Improved "Smart" Robot Hand

Collection of sensor data is speeded a hundredfold.

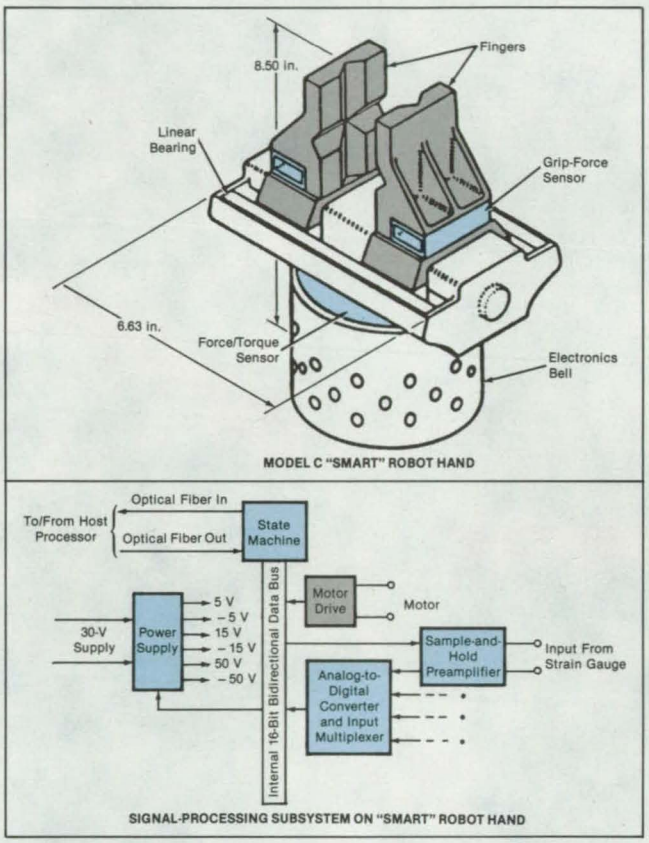
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved version of a developmental "smart" robot hand is equipped with a bidirectional, wide-band optical-fiber link for the transmission of digitized strain-gauge force- and torque-sensor signals from the hand and for the transmission of command signals to the motor drive unit on the hand. The rate of transmission of data to and from the hand is approximately 10 kHz, which is about 100 times that of previous versions. The higher data-collection speed makes it possible to perform advanced processing of the sensor data in a host processor; that is, in a computer located elsewhere than on the hand.

In a typical previous version of the "smart" robot hand, a microprocessor has performed the data-collection and communication functions. This feature tends to limit the speed at which data can be collected. Furthermore, the strain-gauge excitations have been limited to about 12 Vdc because higher applied voltages would heat the strain gauges excessively. However, higher excitations would be desirable because they would increase the signals received from the gauges while leaving noise levels constant. The new design addresses both the speed and the signal-to-noise-ratio/heating issues.

The improved robot hand (see figure) includes an electronic unit called the "state machine," which is a high-speed, custom-designed circuit that generates clock signals and synchronizes and formats incoming command signals and outgoing sensor-data signals. The state machine serves as the interface between the data bus on the hand and the bidirectional, high-speed optical-fiber link. Because of the high bandwidth of the optical link, it is no longer necessary to process the data locally in the hand. All data-processing functions are performed at the host processor, permitting the applicable software to be written in a familiar and convenient development environment.

Because the strain gauges in the improved hand are excited by pulses of only 5-μs duration, the excitation signals can be made as large as 100 V without causing excessive heating. This increase results in a tenfold increase in the signal-to-noise ratios of the sensor outputs. Furthermore, the strain-gauge excitations can be varied via software to vary the full-scale force or torque range. By use of this feature, the digitized sensor outputs can be maintained at 12-bit accuracy, no matter what range is selected.



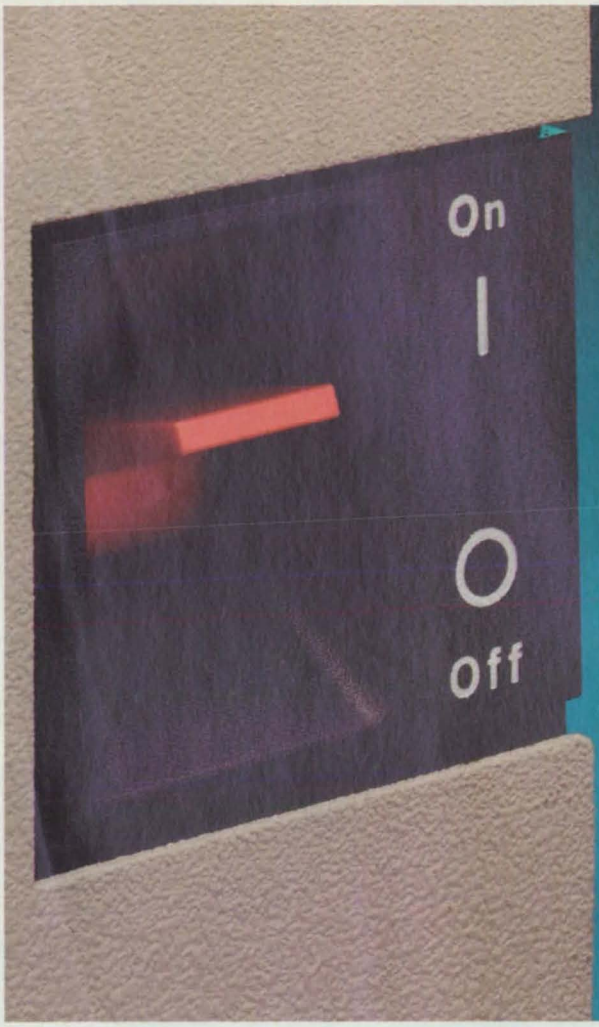
The **Improved "Smart" Robot Hand** features a high-speed electronic data formatter and synchronizer and a high-speed bidirectional optical-fiber link for the transmission of data to and from the host computer.

As the figure also shows, the hand resembles a motorized vise in which two jaw-like fingers move along a linear bearing. The motor is mounted in the middle, between the left-handed and right-handed threads at opposite ends of a spindle, which drives the fingers in opposite directions. This is a direct-drive configuration. Its prime advantage is that the motor is removed from the housing of the electronics to reduce the electrical noise and give more room for the circuits. The fingers are nonbackdrivable, but a backdrivable version could also be built using a ball screw. The advantage of nonbackdrivability is that after grasping, it is not necessary to maintain motor current to hold the object. This results in less dissipation of heat in both the motor and its driver circuit.

The use of more sensitive strain-gauge sensor electronics makes it possible to increase the sizes of the beams of the force-and-torque-sensor portion of the hand. This makes the sensor portion sturdier, so that limit screws are no longer needed. In the original grip-force sensors, the strain gauges were mounted in the middle of the bending beams, where the sensitivity was small. In the new grip-force sensor, the strain gauges are offset to the ends, where the stresses are greatest.

This work was done by Zoltan F. Szakaly, Zoltan Vigh, Antal Bejczy, and Timothy Ohm of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, Circle 86 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 24]. Refer to NPO-17917.



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Circle Reader Action No. 546

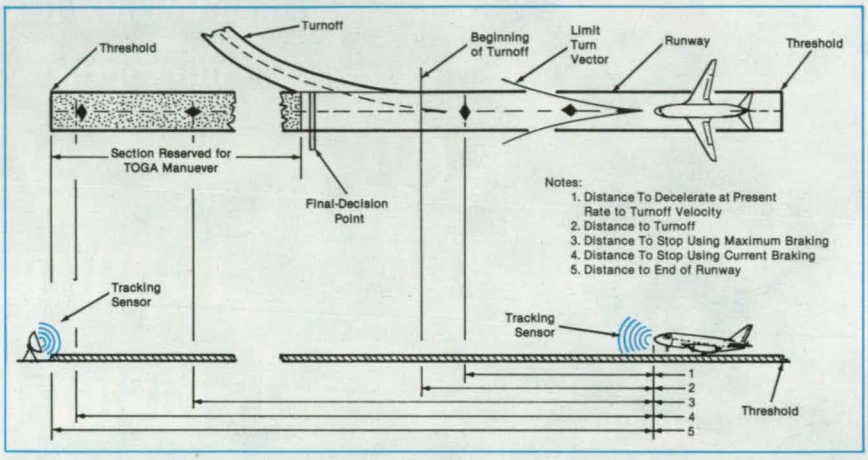
System Predicts Critical Runway Performance Parameters

Reliable current information is provided to pilots for runway-maneuver decisions.

Langley Research Center, Hampton, Virginia

The runway-navigation-monitor (RNM) and critical-distances-process electronic equipment are designed to provide a pilot with timely and reliable predictive navigation information relating to takeoff, landing, and runway-turnoff operations. The predictive data will enable the pilot to make critical decisions about runway maneuvers with high confidence during emergencies. Although a number of runway performance monitors — from simple runway markers to computer-based decision-making algorithms — have been in use, certain limitations exist with all of them. For example, runway markers are hard to read during poor visibility, heads-down monitoring systems increase a pilot's workloads during critical maneuvers, and decision-making algorithms rely on data on the statuses of systems in aircraft. The new technique utilizes ground-referenced position data only to drive a purely navigational monitor system that is independent of the statuses of systems in an aircraft.

The critical runway distances are shown in the figure. In the landing case illustrated, the pilot reserves a section for the takeoff-and-go-around (TOGA) maneuver in case of an emergency. When the aircraft is positioned so that the tracking sensors are within range of each other, the RNM makes it possible for the crew to know continuously the following: the distance to the end of the runway; where the plane will stop if it continues to use the present braking means; where the plane will stop if it uses the maximum braking means; where the plane will achieve the appropriate turnoff velocity if it continues to use the present decelerating means; and when, or where on the runway, the plane will reach the final-decision point for staying safely on the



Predictive Navigation Information independent of the statuses of systems in the airplane is provided continuously during runway maneuvers.

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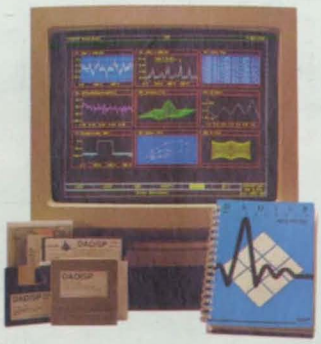

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ground.

The information provided by the RNM also helps the pilot to assess the capability of the aircraft to make the next turning maneuver. As the plane approaches a turn, the pilot compares the radius of the limit turn vector (LTV) with the radius of the painted runway centerline. If the radius of the LTV is equal to or smaller than the radius of the runway centerline at the turnoff, the cornering capability will be sufficient. If the radius of the LTV is greater, the pilot should increase braking or abort the turn maneuver.

The RNM and critical-distances-process equipment have been made possible through the integration of new onboard computational powers, new sensors coupled with avionics, and such new cockpit-display technology as cathode-ray-tube displays and heads-up displays. The RNM process equipment has been kept simple by providing the crew with accurate navigation data supplemented only by the statuses of critically changing distances.

The RNM operates independently of other aircraft systems, regardless of the means used to accelerate or decelerate the aircraft. The continuous predictive information provided by the RNM informs the crew upon touchdown or takeoff whether or not the aircraft can be braked to a stop on the runway, whether it can be slowed sufficiently to make a turnoff, or whether there is sufficient distance to achieve a required takeoff acceleration prior to rotation. These predictions are continuously updated throughout the maneuver, providing the pilot with the necessary information to make decisions about critical runway maneuvers with confidence.

This work was done by Ernest W. Millen and Lee H. Person, Jr., of **Langley Research Center**. *No further documentation is available.* *LAR-13809*

Fast Feature-Recognizing Optoelectronic System

Images would be classified rapidly from parallel readouts of signature vectors.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed optoelectronic system would recognize features or classify images by processing the outputs of photosensors rapidly, in parallel, through circuits developed in research on neural networks. The system would even be able to "learn" new patterns for subsequent recognition. The concept has obvious potential for applications in robotic vision systems and pattern recognition.

The image is projected on a two-dimensional array of photosensors, which could be photodiodes, photovoltaic cells, photosensitive charge-coupled devices, or, as shown in Figure 1, optically modulated resistors made of photoconductive material — possibly hydrogenated amorphous silicon. Each such resistor acts as a synapse, the analog connection strength of which is determined by the illumination in the corresponding pixel of the image.

An amplifier at one end of each row conductor senses the cumulative voltage drop in that conductor because of all the synapses along the row. An amplifier at one end of each column conductor sense the total current contributed by all the synapses along the column. The row and column amplifiers may be called *X* neurons and *Y* neurons, respectively, by analogy with some of the functions of neural networks.

In this scheme, each synapse communicates with an *X* neuron and a *Y* neuron. The data in an image of $N_x \times N_y$ picture elements would be compressed into the analog outputs of the $N_x + N_y$ neurons. These outputs constitute a feature vector of $N_x + N_y$ components.

The analog feature vector is then converted by threshold or lateral inhibition/winner-take-all circuits developed at JPL (with further data compression) into a binary form suitable for subsequent processing. As shown schematically in Figure 2a, the resulting binary signature vector could be presented to a classifying neural network — for example a Hopfield-type neu-

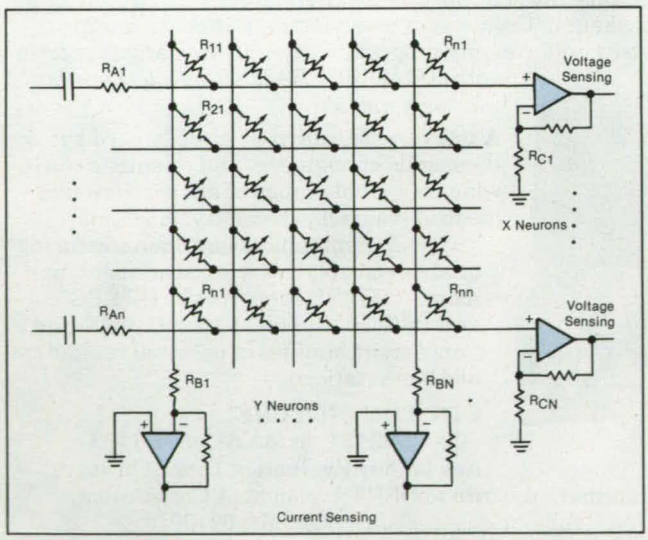

Figure 1. An **Array of Photoconductive Elements** would serve as photomodulated connections in an electronic neural network, which provides high speed data compression to generate a feature vector.

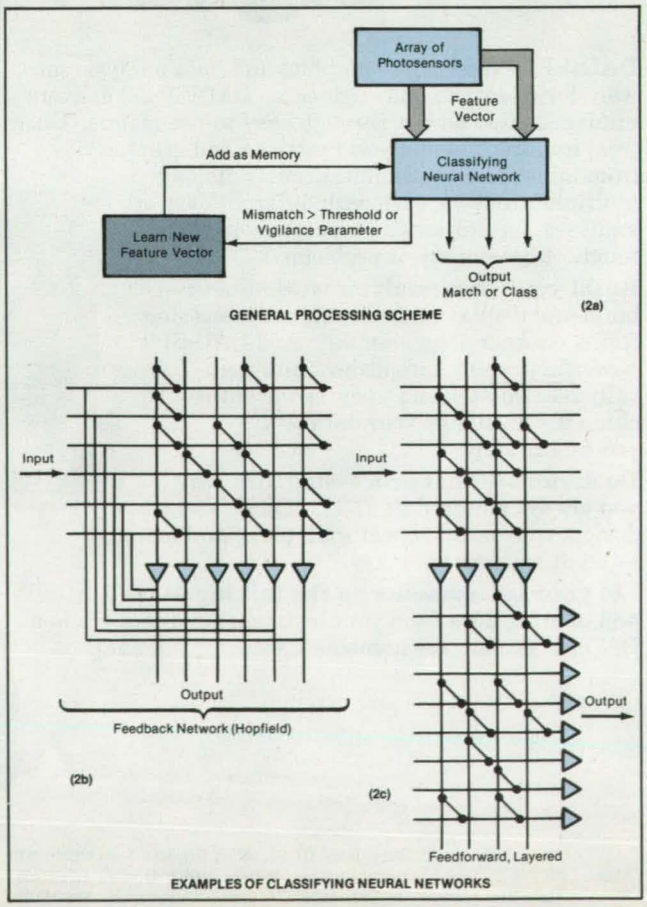

Figure 2. The **Feature Vector**—schematic diagram shows neural network architectures for high speed feature extraction and pattern recognition.

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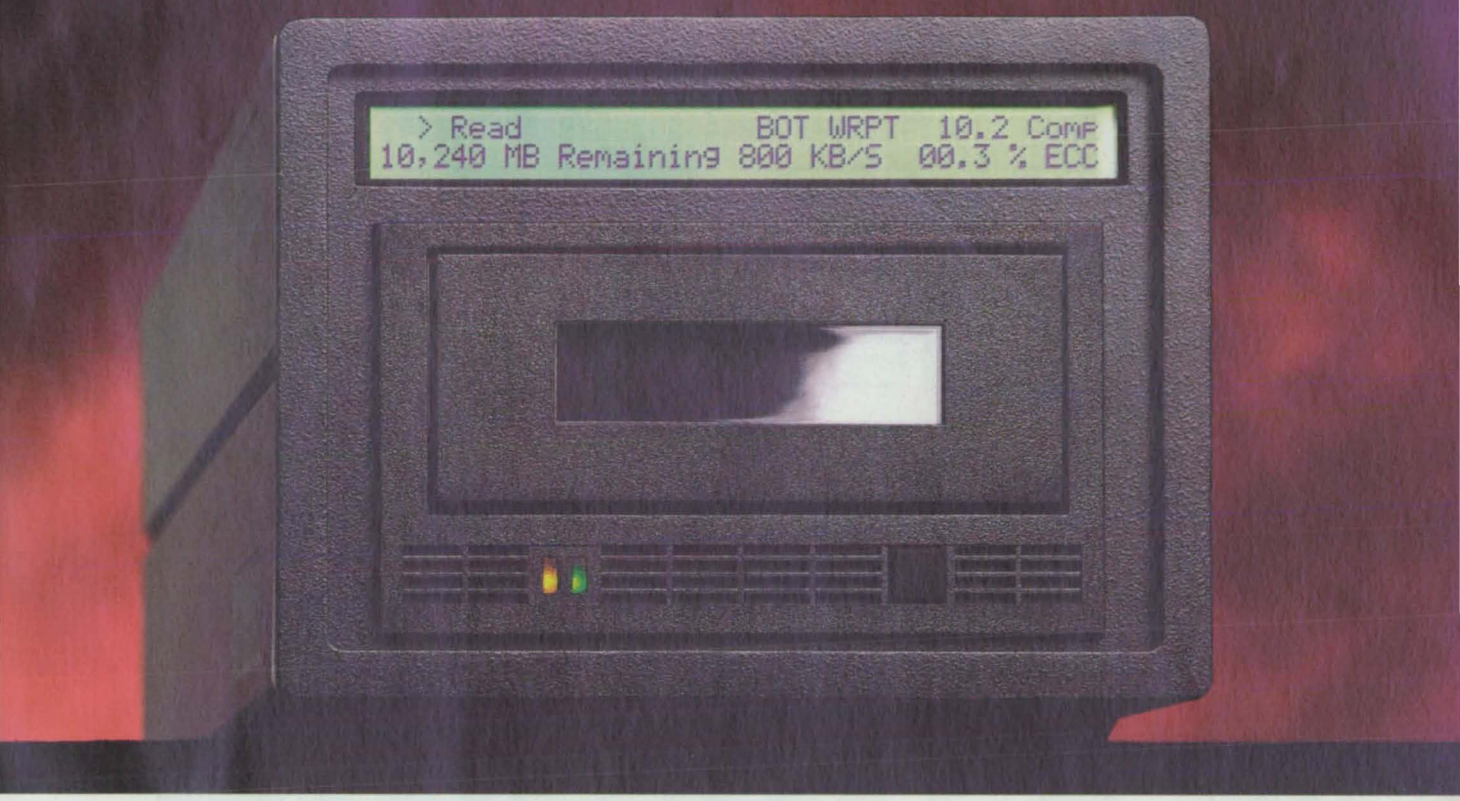

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ral network with feedback, in which signatures representative of all patterns or their categories to be recognized are stable states. As our electronic hardware implementations have already demonstrated, the feedback network (see Figure 2b) generates the best Hamming match (or the best Euclidean match when the analog prompt scheme is employed), at extremely high speed, since the effective search takes place in parallel. Alternatively, a feedforward, winner-take-all circuit decides the best match, based on the highest inner product between the prompting vector and all the stored vectors, all computed in parallel.

The feature vector could also be presented as a prompt to a multilayer feedforward network (see Figure 2c) that has already been "taught" all the patterns to be recognized. If the prompting feature vector matches one of those stored, the correct match or its label is obtained as output. A threshold or vigilance parameter can be dictated to set the level of mismatch for the similarity of patterns. If the mismatch is above the threshold, the system could store a new feature vector for such a significantly new pattern, thus "learning" to recognize the new pattern.

This work was done by S. Thakoor and A. P. Thakoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 80 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 24].Refer to NPO-17690.

Three-Zone Programmable Temperature Controller

Heating by direct current assures low electrical noise.

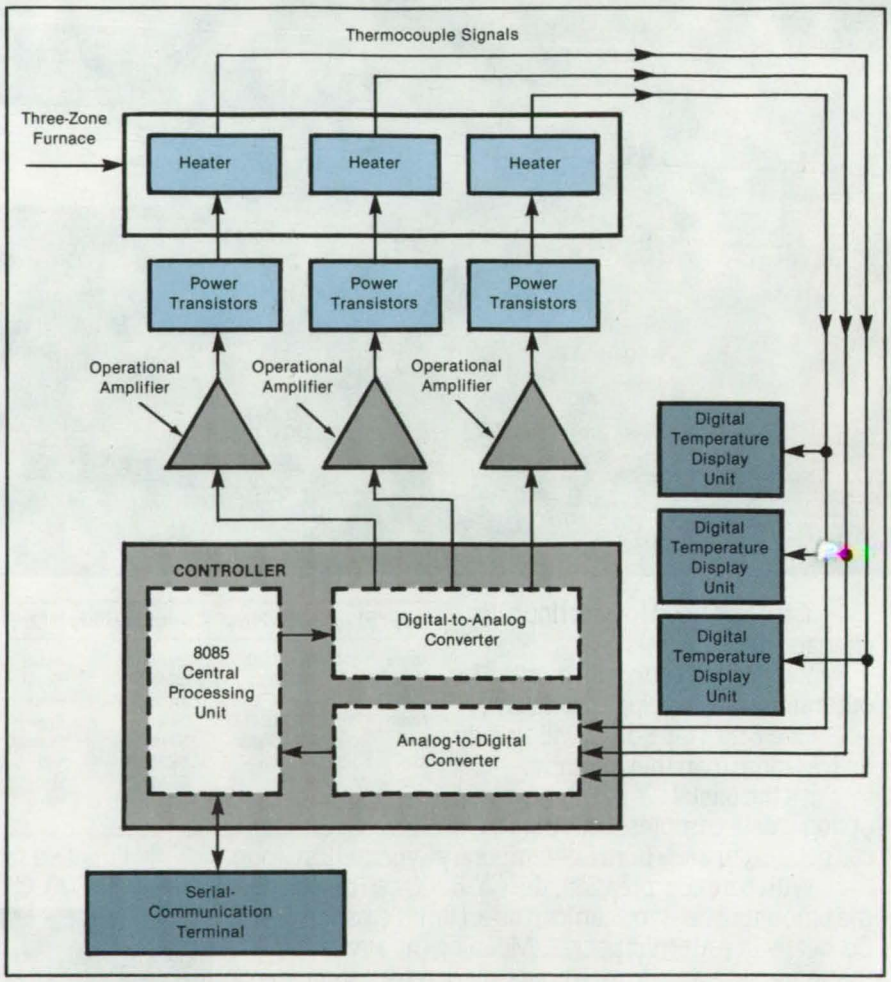
Marshall Space Flight Center, Alabama

A microprocessor-based controller (see figure) regulates the electrical power supplied to the heater in each zone of a three-zone directional-solidification furnace. Although it is intended primarily for use in microgravity experiments aboard a KC-135 airplane, the controller can also be used on the ground. In either environment, it offers the advantage of low electrical noise and consequent minimal interference with the low-level signals put out by thermocouples and other sensors used in the experiments. This advantage is achieved by heating with direct (instead of alternating) current and not pulsing the heating current.

The controller adjusts the current to each heater (0 to 6 A) by adjusting the voltage applied to the gates of a pair of parallel metal oxide/semiconductor field-effect transistors. Because they are intended to operate in the active regions of their current-vs.-voltage characteristics, the power transistors are mounted on heat sinks. The control signals are generated by a digital central processing unit, fed through a digital-to-analog converter, then fed to three operational amplifiers of gain 2, then to the power transistors.

The central processing unit (CPU) includes an 8085 complementary metal oxide/semiconductor (CMOS) microprocessor and two CMOS electrically programmable read-only memories (EPROM's). Thermocouple signals that indicate the temperatures in the three zones of the furnace are fed to three digital temperature-display units and to the CPU through an analog-to-digital converter. The digitized temperature signal from each zone is averaged over 16 consecutive sampling periods, then fed to the CPU, which compares it with the specified zonal temperature and commands an adjustment of the corresponding heater current to bring the temperature toward the specified value.

The operator communicates with the controller via a keyboard on a serial-communication unit. When the controller is first turned on, control software in the EPROM's sets the initial operating mode. The operator is prompted to specify the temperature for each zone. To prevent premature burnout by limiting the maximum current applied to each heater, the software limits the commanded rate of increase of temperature in each zone to about ½ °C/s. At any time, the operator can press the "escape" key, causing the controller to turn off the heater currents and ask the operator to specify new zonal temperatures.



The **Temperature Controller** provides proportional control of the dc heater current in each heater in a three-zone furnace.

This work was done by Guy A. Smith and L. Workman of the University of Alabama in Huntsville. For further information, Circle 88 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28435.

LIFE SUPPORTING PLANTS SUPPORTING LIFE

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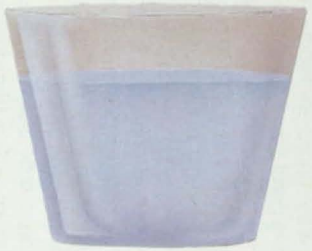
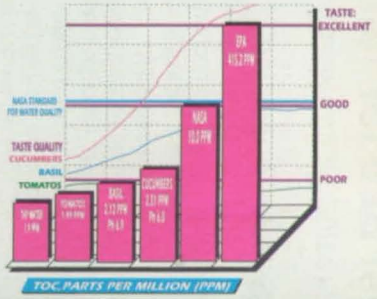
Hello, my name is Jeffery Julian DeMarco, president and founder of Pyraponic Industries, Inc. II and inventor of the Phototron®. Based on the proof of principle that I unveiled at the 20th International Conference on Environmental Systems (ICES) in Williamsburg, Virginia, the Phototron® is an artificial biosphere that controls and standardizes an ecosystem of plants. Potentially a permanent life support element on Space Station Freedom, the Phototron® is a biological water and air reclamation and recycling chamber that uses the natural filtering of plants to produce and maintain sufficient supplies of potable water and food for terrestrial and extra terrestrial habitation.

Current prototypes housing a variety of plants including tomatoes that were grown from seeds contained aboard the Long Duration Environmental Facility (LDEF) in space for six years have shown that one Phototron® is theoretically capable of transpiring up to one gallon of potable water every 24 hours. This is based on one unit of plant mass which equals a 45 inch by 22 inch area of living plant material, including root zones. Besides tomato plants, basil and cucumber plants have been examined for water reclamation capacities within Phototrons®. Test results thus far (see chart) have demonstrated readings of Total Organic Carbons (TOC) at 2.32 ppm +/-0.05. Current NASA standards and specifications for hygiene water on Space Station and all future manned missions call for Ph readings between 6.0 and 8.0, and TOCs less than 10.0 ppm.



Current theories encorporated in the Phototron® are being applied to define the parameters for recycling human urine through natural plant transpiration. The goal is to create an equilibrium for sustained human life in space for extended periods of time. A single Phototron® controls the growth and production rates of up to six mature plants. The process is felt to utilize six steps; Step 1: Water or urine enters the Phototron® through the Sphagnum moss growing medium. Step 2: The natural microbes in the Sphagnum react and detoxify the water, acting as a biologically enhanced carbon filter. Step 3: The outer surface of the roots act as a semi-permeable membrane. Step 4: The natural metabolic ability of plants acts as a pump to move the water through the roots to the stem and outward to every leaf. Step 5: Evapotranspiration, a process very similar to human sweating, moves the water into the first of two phase changes. As water transpires from the leaves it is transformed from a liquid to a vapor and is released from the plant in the form of water vapor. Step 6: The water vapor exits the Phototron® and is condensed on inert coils cooled to a temperature below the dew point. This constitutes the second change, transforming the vapor back to a liquid state.

The goal is to feed urine to plants within a Phototron®, and produce pure drinking water. This process is sophisticated and elegant. Coupled with tissue culture at the gene level, we plan to produce a plant that is a super purifier. Using new techniques, in conjunction with the Art Freytag Tissue Culture Institute, it is our goal to produce a plant that can be grown optimally grown on or even depend on urea, one of the primary contaminants in urine, as a major food source. In this manner, the nitrogen from urea could be used to "feed" the plants, and the resulting transpiration can be used for drinking water.



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Test Bed for Telerobots

A versatile system keeps up with new technology.

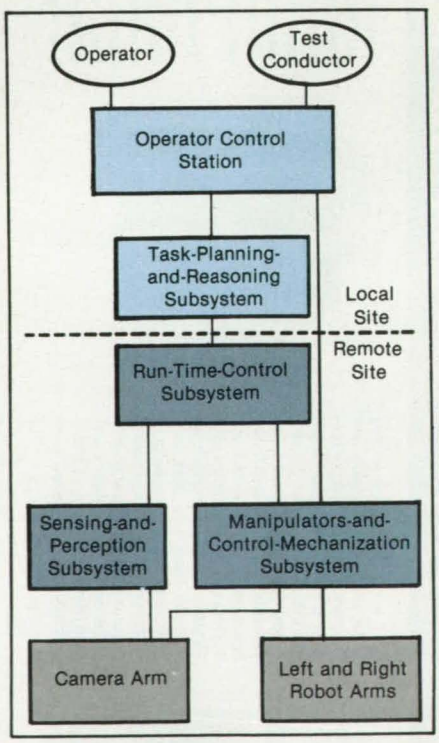
NASA's Jet Propulsion Laboratory, Pasadena, California

An assembly of electromechanical and electronic equipment (including computers) constitutes a test bed for the development of advanced robotic systems for remote manipulation. Although intended primarily for robots to be used in outer space, the test bed could be adapted to the development of advanced terrestrial telerobotic systems for handling radioactive materials, dangerous chemicals, and explosives.

The test bed serves as an interface among the human operator, the human test conductor, and the telerobot for evaluation of the ability of the telerobot to perform such tasks as mechanical assembly and disassembly, mating electrical components, in-flight and preflight inspections, refueling, removal of debris, and rescues. The test bed contains subsystems for machine vision, teleoperation, autonomous control, and planning of motions. It is designed to facilitate enhancement with such features as operation with time delay, operation in cluttered surroundings, and dexterous manipulation by incorporation of commercially available cameras, computers, robot arms, and other equipment.

The operator control station of the test bed (see figure) includes two computer workstations equipped with video monitors, a stereo vision display, two force-reflecting hand controllers, emergency-halt buttons, and computers for the maintenance of internal status and communication with other subsystems.

A task-planning-and-reasoning subsystem gives the operator supervisory control over autonomous operations of the telerobot. It enables the operator to plan tasks and gross motions at a high level. It accepts task assignments and direct requests for action from the operator and translates high-level tasks into processes for remote execution by the run-time-control subsystem described in the next paragraph. It maintains a data base of objects in the workspace and the relationships between the objects and the capabilities of



The Test Bed Combines Features not found in commercial systems. Its architecture allows easy growth in complexity and level of automation. The system is a national resource for the validation of new telerobotic technology.

the telerobot.

The run-time-control subsystem provides fine-motion and grasp-planning commands for the arms of the telerobot. It detects collisions.

The sensing-and-perception subsystem furnishes the operator with up to five still or live video images. It provides machine-vision stereo images to its object calibration algorithms. It tracks moving objects, supplying estimates of the positions, orientations, translational velocities, and angular velocities of the objects to the task-planning-and-reasoning subsystem.

The manipulators-and-control-mechanization subsystem includes the robot arms and end effectors and force and torque sensors. It also includes universal controllers programmed to generate trajectories, exert servocontrol, and communicate with other equipment.

This work was done by Jacob R. Matijevic, Wayne F. Zimmerman, and Shlomo Dolinsky of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 135 on the TSP Request Card.*
NPO-17898

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Evaluation of an Aircraft-Collision-Avoidance System

Data from simulated flights show that the system helps pilots avoid near misses.

A report describes a study of pilots' use of a traffic alert and collision-avoidance system (TCAS II) in simulated airplane flights. The report describes the methodology, summarizes the results, and presents conclusions.

TCAS II gives an alert by light and sound when another aircraft is within 40 s of passing very closely. If the other aircraft still poses a threat 15 to 20 s later, TCAS II advises the pilot to maneuver vertically or to continue on the same flightpath but alter the rate of ascent or descent.

The subjects for the study were 16 airline flightcrews composed of 3 persons each. Each crew flew the same 8 simulated flight segments during a 10-h simulated duty day. Each crew was exposed to the same conflicting aircraft under full air traffic control. Each crew flew under one of the following conditions:

- No TCAS II on the aircraft (in all cases, a simulated Boeing 727 airplane);
- A minimal TCAS II, without a display of conflicting traffic;
- TCAS II with a display that showed traffic only when a conflict occurred; or
- TCAS II with a full-time display of traffic in the vicinity.

The study showed clearly that TCAS II helps pilots avoid close encounters. Without TCAS, in 4 instances, the minimum separation between aircraft decreased to less than 1,000 ft (305 m) horizontal and 200 ft (61 m) vertical simultaneously during 32 flight segments. In one case, the minimum separation was less than 500 ft (152 m) horizontal and 100 ft (30 m) vertical. With TCAS, in no case during 96 flight segments were aircraft separated by less than 1,000 ft horizontal and 200 ft vertical.

The amount of information on the loca-

tion of conflicting air traffic had little influence on the appropriateness of the responses of those crews who had TCAS II. Responses were equally effective whether pilots had sound and light indicators only, a part-time display, or a full-time display. When pilots had displays, however, they took avoidance actions earlier and perhaps prematurely, before they observed the conflicting aircraft visually.

This work was done by Sheryl L. Chappell, Charles E. Billings, and M. Christine Olsen of **Ames Research Center**, *Barry C. Scott of the Federal Aviation Administration, Robert J. Tuttell of the Naval Postgraduate School, and Thomas E. Kozon of Sterling Software Corp. Further information may be found in NASA TM-100094 [N89-18037], "Pilots' Use of a Traffic Alert and Collision-Avoidance System (TCAS II) in Simulated Air Carrier Operations — Volume I: Methodology, Summary, and Conclusions."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12367

Details of Collision-Avoidance Study

Plans, forms, training narratives, scripts, questionnaires, and other information are compiled.

A report provides background information on and a detailed description of a study of pilots' use of a traffic-alert and collision-avoidance system (TCAS II) in simulated flights. The study is described in the preceding article, "Evaluation of an Aircraft-Collision-Avoidance System" (ARC-12367). The document contains the following parts:

- TCAS Information Transfer: Handbook for Air Carrier Flightcrews: This document describes the experiments to be conducted for the flightcrews who were to serve as subjects. It gives background information on TCAS II, the schedule of the experiments, the procedures and equipment to be used, and other incidental information about the study.
- Flight Plan and Aircraft Load Data: This document describes scenarios for the simulated flights, including information on the aircraft, cargo, fuel, routes, altitudes, and schedules. The scenarios were submitted to the participating air carriers so that they could prepare flight plans and dispatch papers in the form most familiar to the subjects.
- Subject Flight Time Questionnaire: This is a form that was filled out by each crew-

member on arrival at the experiment site. It asks questions about age, cockpit position, flying time, and other facts pertinent to the subjects' flight experience.

- TCAS Experimental Design: This document describes the experiment, the types of TCAS, conditions to be simulated, subject groupings, equipment, and procedure.
- Training Narratives: These are three training texts. Each covers one of the TCAS II systems used in the experiment: without traffic display, with traffic display only during conflicts, and with continuous display of traffic. These narratives tell subjects how the system works, what to expect, and how to react.
- Description of Simulation Computer Integration: This document describes the aircraft simulator and its computer hardware and software.
- Subject Information Form: This form enabled the subjects to request reports on the experiment.
- Experimenter Checklist and Subject Briefing Outline: This is a list of procedural items.
- Quiz on TCAS, Used During Training: The title is self-explanatory.
- TCAS Airplane Flight Manual Supplement: This is an attachment to the FAA-approved flight manual for Boeing 727 aircraft equipped with TCAS.
- Forecast and Actual Weather: This document describes weather on the simulated flight routes.
- Air Traffic Control Script: This is the script followed by controllers in their communications with crewmembers in the simulator.
- Encounters Used in the TCAS Experiment: This is a list of simulated conflicting aircraft in each flight segment, including a description of the aircraft and their positions with respect to the subjects' simulated airplane.
- Data Forms Used by Observers: These are forms filled out by observers for each simulated encounter. The forms were used to analyze the crews' responses.
- Workload Rating Scales: These are rating sheets filled out by subjects after each flight segment. They provide scales for rating the magnitude of mental demand, physical demand, temporal demand, and other factors.
- TCAS Postflight Questionnaires: These are forms used by subjects during debriefing sessions to evaluate TCAS II.
- Verbal Debriefing of Subjects. These are forms used to record informal comments of subjects.
- Human Factors of the TCAS II Collision-Avoidance System: Maneuvers Based on Resolution Alerts: This is a report, based on the results of the study, on the effect of corrective resolution advisories on separation between conflicting aircraft.
- Use of the TCAS Traffic Advisory Display for Evasive Maneuvering: This is a report on 14 incidents, during the simulations, of maneuvering prompted by traffic-advisory displays.
- Postflight Questionnaire Results: These are averages of the responses of subjects to questions on the postflight questionnaire.

This work was done by Sheryl L. Chappell, Charles E. Billings, and M. Christine Olsen of **Ames Research Center**, *Barry C. Scott of the Federal Aviation Administration, Robert J. Tuttell of the Naval Postgraduate School, and Thomas E. Kozon of Sterling Software Corp. Further information may be found in NASA TM100094 [N89-18038], "Pilots' Use of a Traffic Alert and Collision-Avoidance System (TCAS II) in Simulated Air Carrier Operations — Volume II: Appendices."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703)487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12396

Physical Sciences

Hardware, Techniques, and Processes

Adjustable Induction-Heating Coil

Three segments can be adjusted independently to obtain the desired distribution of temperature.

Lewis Research Center, Cleveland, Ohio

An improved design for an induction-heating work coil facilitates the optimization of heating in different metal specimens. For the past 30 years, radio-frequency induction has been an accepted method of heating metallic specimens for mechanical testing. However, the establishment of the optimum work-coil configurations to give uniform temperatures over the gauge lengths of specimens has remained a "black art."

Heretofore, a typical induction-heating work coil has been wound from a single length of copper tubing. The work-coil configuration best suited for a particular experiment is determined by trial in a series of experiments on suitably instrumented specimens. Variables of interest include the diameter, overall length, number of turns, spacing of turns, and grouping of turns of the coil. The optimization of these variables by trial and error is time-consuming and frustrating.

The approach adopted in the improved design was simply to subdivide the work coil into three segments (see figures). Each segment is attached to a positioning mechanism that enables independent adjustment along both the vertical (axial) and radial (in this case, horizontal) axes. Short lengths of copper tubing at the rear of the assembly are used to connect the three segments of the coil in series. The assembly is connected to the induction-heater power supply by two flexible power leads.

Both a 5-kW radio-frequency (450-kHz), and a 50-kW audio-frequency (9.6-kHz) induction heater have been used successfully with this fixture for many high-temperature material-deformation tests. Temperature profiles in these experiments varied only within ±3 °C of the nominal test temperatures over a ½-in. (13-mm) specimen gauge length.

The use of this fixture has significantly reduced the time needed to achieve required temperature profiles. This results primarily from the capability to make adjustments to one coil segment without affecting the other two. It is worth noting that the concept of the segmented coil allows up to three different coil diameters to be used without difficulty to form a work coil. Also, the direction of the coil winding can be reversed with minimum complication in this approach.

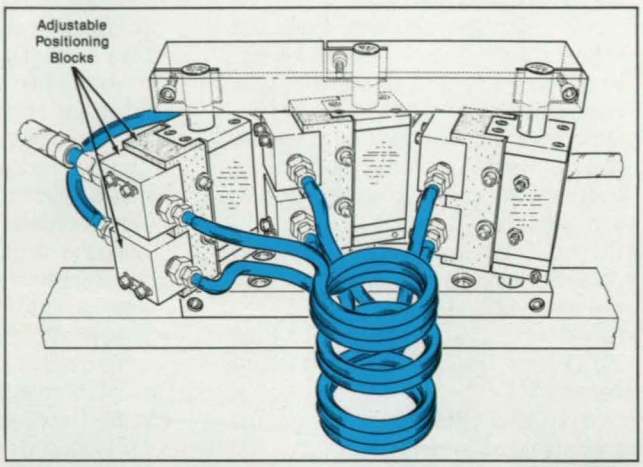


Figure 1. The **Induction-Heating Coil** is divided into three segments, each of which can be positioned independently.

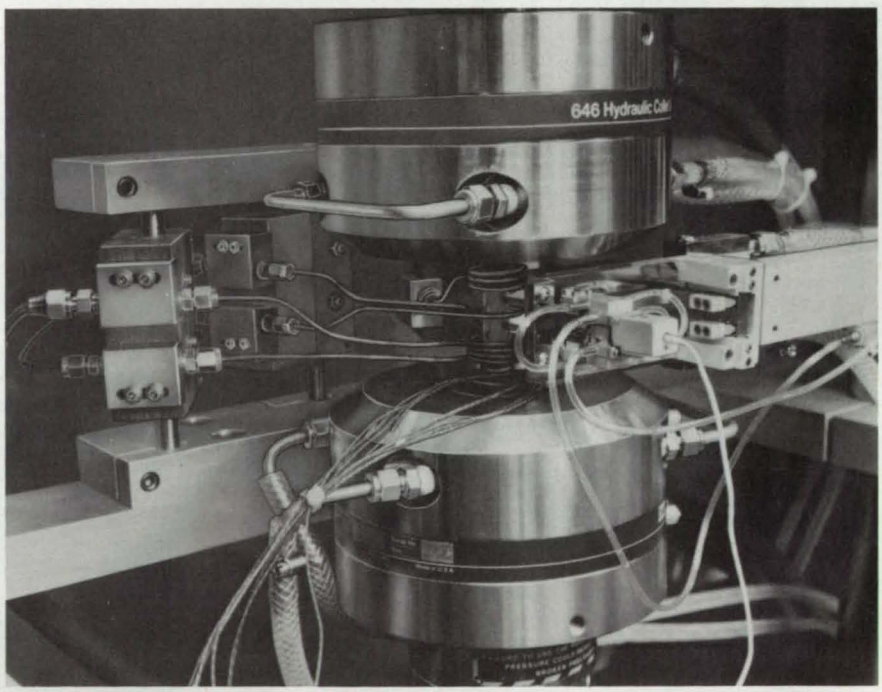


Figure 2. A **Uniaxial Specimen in a Thermochemical Test System** is heated by a 5-kW, three-segment coil like those illustrated in Figure 1.

This work was done by Rod Ellis and Paul Bartolotta of **Lewis Research Center**. *Further information may be found in NASA TM-100151 [N87-26399], "A High Temperature Fatigue and Structure Testing Facility."*

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Fiber-Optic Coupler and Dynamic-Range Enhancer for CARS

Simpler equipment yields higher coupling efficiency with fewer adjustments.

Langley Research Center, Hampton, Virginia

In an improved, more efficient scheme for coupling a coherent anti-Stokes Raman spectroscopy (CARS) signal from a measurement volume to a monochromator, an optical fiber and two lenses are used in place of a previous complicated system of mirrors, prisms, and lenses that required many adjustments and exhibited poor coupling efficiency. Complementing the improved fiber-optic coupling scheme is an improved scheme for splitting the beam of light in the monochromator to enhance the dynamic range. A large dynamic range is necessary because in CARS (which is used to determine temperatures and concentrations of species in chemically reacting flows), the intensities of the signals vary by factors of the order of 100 as temperatures in measurement volumes rise from ambient to typical combustion values.

In the improved coupling scheme (see Figure 1), numerical apertures are matched and magnifications are chosen so that the dimensions of the final image of a spectral line nearly match those of one of the photodiodes in the linear array of photodiodes that constitute the detector in the spectrometer. The optical fiber has a diameter of 50 μm and a numerical aperture of 0.2; the beam leaving the fiber is recollimated by a 10× microscope objective lens that has a numerical aperture of 0.25. A vertical cylindrical lens of 75-mm focal length focuses the beam in the horizontal plane to a width of 0.22 mm and a numerical aperture of 0.05 (approximately matching that of the monochromator) at the input location of the monochromator. A horizontal lens of 100-mm focal length focuses the beam in the vertical plane to a height of 2.0 mm (matching that of a photodiode) and a numerical aperture slightly less than that of the monochromator, so that the beam underfills the mirrors and grating of the monochromator.

For enhancement of the dynamic range, the beam is split inside the monochromator (see Figure 2). An optical wedge (or several such wedges) in the collimated beam between the first mirror and the diffraction grating deflects a portion of the beam horizontally through a small angle to produce a secondary image. The intensity of each secondary image depends on the size, angle, and location of the wedge(s). When the input intensity is high, one of the secondary images is selected as the primary image is saturated (over the range of the detector) and is therefore meaningless.

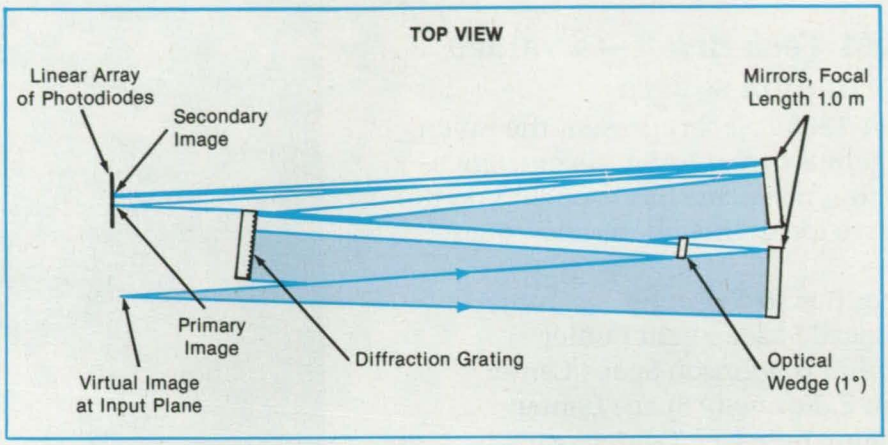

Figure 1. **Cylindrical Lenses** focus light from an optical fiber into a beam of approximately rectangular cross section at the input plane of the monochromator.

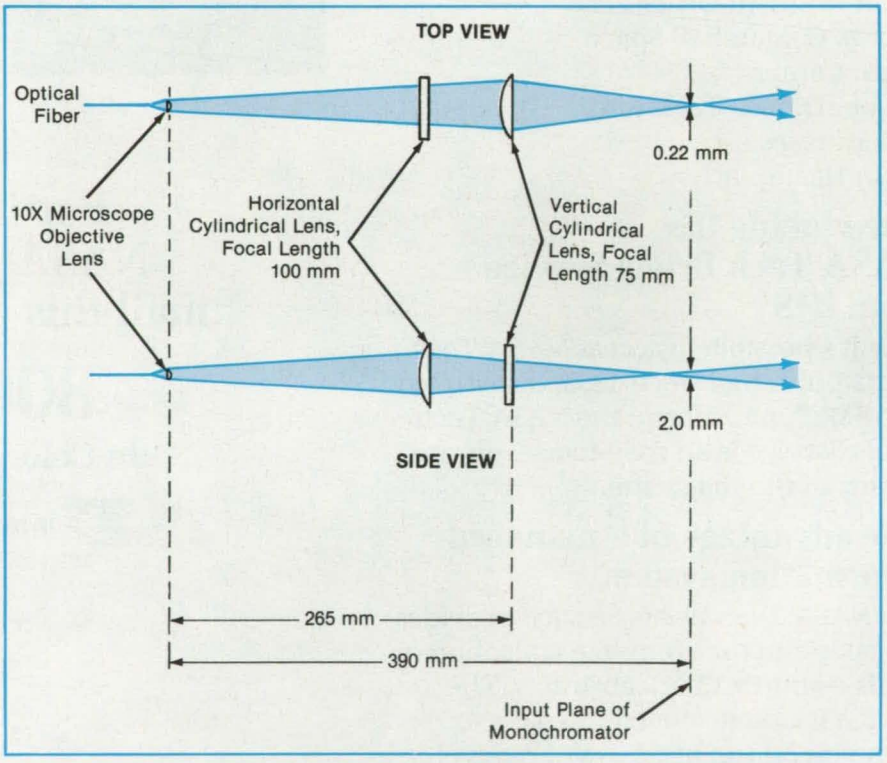

Figure 2. An **Optical Wedge** diverts part of the beam in the monochromator to produce a less-intense secondary image.

This work was done by Andrew D. Cutler of George Washington University for **Langley Research Center**. *For further information, Circle 9 on the TSP Request Card.*

LAR-14235

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KD_2PO_4 Polarization Modulator With Large Field of View

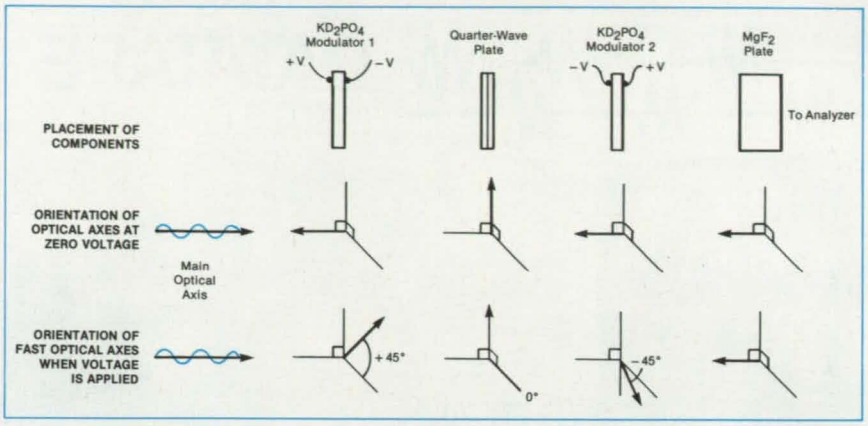
Errors previously caused by convergence of light are expected to be eliminated.

Marshall Space Flight Center, Alabama

An improved potassium dideuterium phosphate (KD_2PO_4) electro-optical linear-polarization modulator is suitable for use with optical instruments that have large (that is, wide-angle) fields of view. In principle, a KD_2PO_4 electro-optical modulator of prior design can work perfectly if the input beam of light is parallel or nearly so (representing a narrow field of view), because at directions of incidence along the main optical axis, spurious effects that arise from the combination of the Pockels (linear electro-optical) effect and birefringence in the KD_2PO_4 crystal are zero. These effects appear and increase, giving rise to output errors that increase as the angle between the direction of incidence and the main optical axis increases from zero. Thus, prior KD_2PO_4 polarization modulators have been limited to operation in small fields of view. In the improved polarization modulator, the errors are suppressed in large fields of view.

The improved polarization modulator includes the following components (see figure):

- A KD_2PO_4 modulator (modulator 1), the fast axis of which lies at +45°;
- A quarter-wave plate, the fast axis of which lies at 0°;
- A KD_2PO_4 modulator (modulator 2), the fast axis of which lies at −45°; and
- A plate of MgF_2, which is a positive uniaxial crystal. The modulated polarization is oriented at ±45°. The thickness of the MgF_2 plate is selected to correct the field-of-view errors of the two KD_2PO_4 modulators. The fast axes of the two KD_2PO_4 modulators are crossed in such a way that their modulation errors, including both retardation and field-of-view errors produced by the applied voltage, are canceled out.



The **Linear-Polarization Modulator**, shown here schematically, corrects modulation errors that, heretofore, have reduced utility in wide-angle fields of view.

By the insertion of a quarter-wave plate at 0°, the overall polarization monitor can be made to rotate linear polarizations from the ±45° orientations to the 0° orientation. Therefore, the MgF_2 plate is the "natural" birefringence corrector for the KD_2PO_4 modulators, and modulator 1 is the field-of-view corrector for the biaxial errors produced by the Pockels effect. Similarly, if the analyzer is set at 90°, then modulator 2 corrects the Pockels errors of modulator 1. (The analyzer could also be set at other orientations, with the modulated linear polarization at ±45° from the analyzer position. This feature simplifies the alignment of an instrument that incorporates the polarization modulator.) The ultimate polarization resolution of the polarization modulator is limited by the accuracy of the quarter-wave plate, the properties of the KD_2PO_4 crystals, and the matching of thickness of the MgF_2 plate.

This work was done by Edward A. West of **Marshall Space Flight Center.** *For further information, Circle 152 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28418.

Two Radiative/Thermochemical Instruments

Measurements of absorption and emission complement thermal measurements.

Lyndon B. Johnson Space Center, Houston, Texsas

Two laboratory instruments for research in combustion and pyrolysis are equipped for radiative as well as thermal measurements. One instrument is essentially a differential scanning calorimeter (DSC) modified to detect radiation emitted by flames. It provides means to evaluate the limits of flammability of materials that exhibit exothermic reactions in DSC's. The other instrument is used to determine the pyrolysis properties of specimens exposed to various gases by measurement of infrared absorption spectra of the pyrolysis products.

The first mentioned instrument is illustrated schematically in Figure 1. A light pipe made of fused silica fibers or a sapphire rod conducts light from a hole in the DSC lid to a photodiode. A gap between the end of the light pipe and the lid permits the venting of the combustion products. The flow of the reactant gas (e.g., oxygen) through the chamber is regulated by a mass-flow controller. The version shown here operates at atmospheric pressure, but a high-pressure DSC housing could also be modified to accommodate the light pipe.

In operation, the photodiode detects the infrared and/or visible light emitted by the burning of the specimen in the reactant gas. The output of the photodiode is amplified, recorded, and correlated with the thermal data from the DSC. The photometric detection of the flames, coupled with the detection of an exothermic reaction by the DSC, provides an indication of the threshold of flammability of the specimen.

The second mentioned instrument is illustrated schematically in Figure 2. It is based on an instrument designed to measure the autoignition temperature of the specimen in the reactant gas. The specimen is placed in a sample boat in a quartz tube near the center of a tube furnace. A thermocouple measures the temperature of the specimen. As in the first mentioned instrument, a mass-flow controller regulates the flow of reactant gas. The pyrolysis products flow through a quartz tube to an optical-beam test cell, the end windows of which are transparent in the infrared. Infrared radiation of known spectrum is transmitted through the test cell

and into an infrared-absorption spectral analyzer. The reaction can also be monitored visually.

During operation, the temperature in the tube furnace is increased gradually while the infrared absorption spectrum of the gas in the test cell is monitored for spectral indications of pyrolysis products. By measuring the intensities of the spectral absorption bands (and, thereby, the concentrations) of the pyrolysis products as functions of the temperature of the specimen and/or of time, one can determine such pyrolysis properties of specimens as decomposition thresholds and autoignition temperatures.

This work was done by Ralph M. Tapphorn, Dwight D. Janoff, and Richard M. Shelley of Lockheed Engineering and Sciences Corp. for **Johnson Space Center**. *For further information, Circle 120 on the TSP Request Card.* *MSC-21639/MSC-21640*

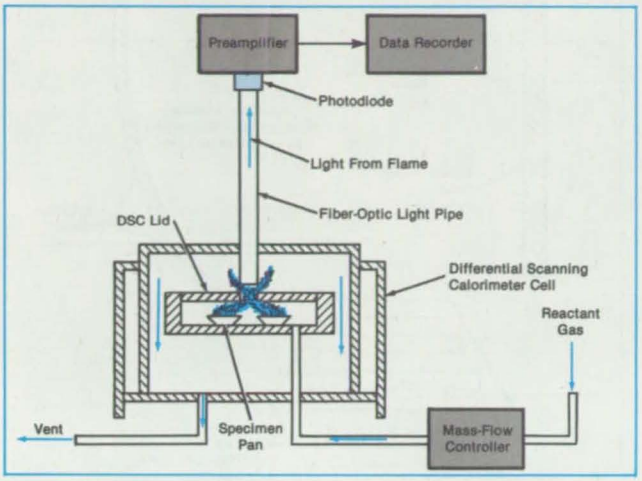


Figure 1. A **Differential Scanning Calorimeter** is augmented with a photodiode and associated circuitry to measure light emitted by burning specimens.

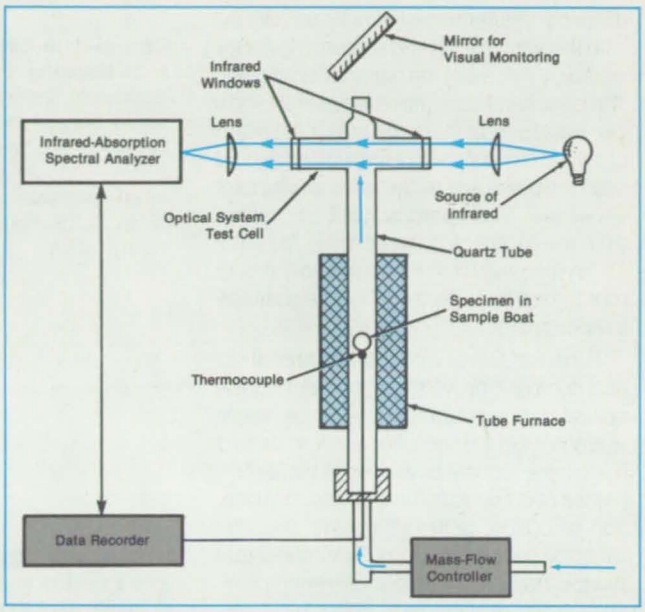


Figure 2. **Pyrolysis Products** from the heated specimen are analyzed by absorption of infrared radiation in the optical-beam test cell.

Two-Wavelength Optical-Path-Difference Mapping

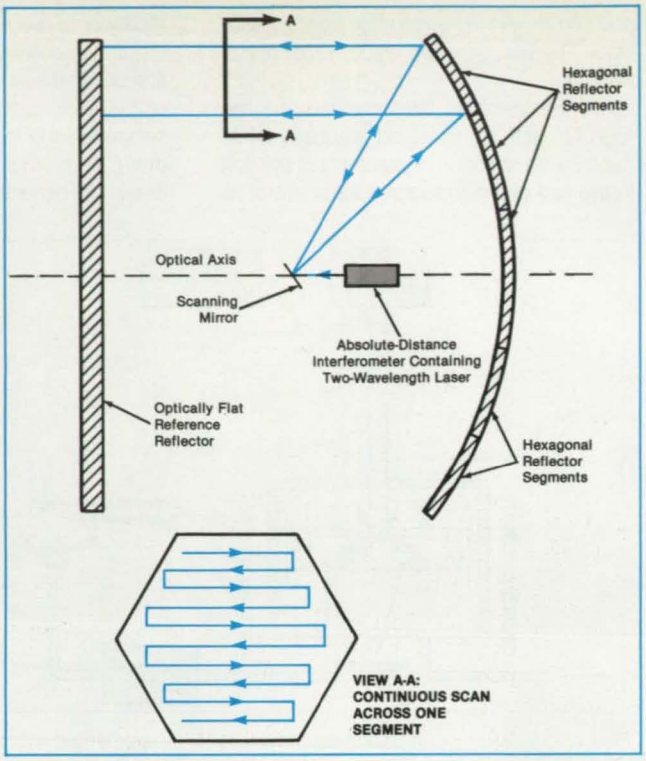
The shapes and alignments of aspherical mirrors could be measured readily.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed technique for measuring the shapes and alignments of reflectors is based on the use of a two-wavelength absolute-distance interferometer to generate optical-path-difference maps of the reflecting or refracting surfaces. The technique could facilitate such tasks as determining the manufacturing and alignment errors of an off-axis segment of a large-aperture paraboloidal telescope mirror, or aligning all the segments of such a mirror. The technique would be suitable for use where reflecting surfaces are highly aspherical, initial misalignments may be large, and/or surface errors exceed optical wavelengths. This is because absolute-distance interferometry, which does not involve the counting of interference fringes in fringe maps, has a dynamic range greater than that of prior interferometric reflector-testing techniques that do involve the counting of such fringes.

In one version of the technique (see figure), the optical-path-difference map would be generated from measurements of the changes of the lengths of optical paths from the common focal point of the segments of a test mirror to an optically flat autocollimating reflector perpendicular to the optical axis of the aspherical mirror. The absolute-distance interferometer would be aligned with the optical axis, and a scanning mirror would be placed at the nominal focal point. The laser in the absolute-distance interferometer would send a thin two-wavelength beam of light to the scanning mirror, which would scan the beam across the reflector segment under test. The beam would be reflected from the segment to the optically flat autocollimating reflector, then back to the segment, then back to the absolute-distance interferometer.

If the test mirror were perfect and all optical components were perfectly aligned, the optical path would have the same length at any point in the scan. For a real, imperfect mirror, the optical-path length varies. By means of computational analysis, the variation of optical path differences over the reflector surface could be minimized and mapped with respect to a reference point, and errors of alignment could be distinguished from errors of manufacture. The alignments of the segments could then be adjusted to minimize the optical-path differences. Because all segments would be scanned from a common focus, all the segments would thereby become coaligned and cofocused with each other.



Optical-Path-Difference Mapping of an aspherical reflector would be performed by use of two-wavelength absolute-distance interferometer in an autocollimator configuration.

This work was done by Paul K. Manhart of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 157 on the TSP Request Card.*
NPO-17725

Microphone Detects Waves in Laminar Boundary-Layer Flow

Long-wavelength interference is suppressed in the microphone.

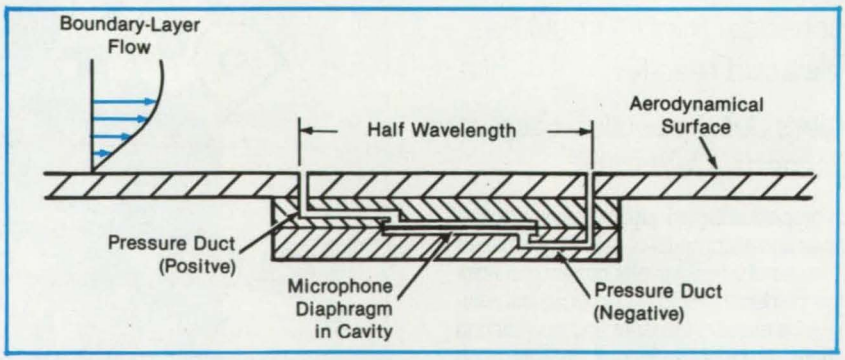
NASA's Jet Propulsion Laboratory, Pasadena, California

A simple noninvasive acoustical technique has proven effective in the measurement of instability waves, which precede the onset of turbulence in laminar boundary layer flows. Such measurements are important in research on aerodynamic flows and may have potential applications in the control of turbulence (with consequent reduction of drag) on aircraft.

In this technique, the pressure oscillations due to the passage of the instability waves are detected by a modified microphone; commercially available microphones that cost only $1 (1987 prices) have been found to have excellent sensitivity. The microphone is mounted inside the airfoil or other aerodynamic model (see figure). The microphone cavity communicates with the flow via two pressure ducts and two small orifices on the aerodynamic surface. One orifice and duct leads to one side of the microphone diaphragm, while the other duct and orifice lead to the other side of the microphone diaphragm. Thus, the microphone measures the difference between the pressures at the two orifices.

The distance between the orifices is chosen to be half the wavelength of the pressure waves to be measured. Because the pressure of these particular waves is in antiphase at the two orifices, in effect the microphone detects double the pressure signal of these waves. On the other hand, because the background noise tends to contain waves of much greater length, the background pressure disturbances that reach the diaphragm are mostly in phase with each other, resulting in small or zero pressure differences across the diaphragm. Therefore, the background noise contributes little or nothing to the output of the microphone. This ability to discriminate against background noise is especially important because the pressure waves to be measured can be relatively weak.

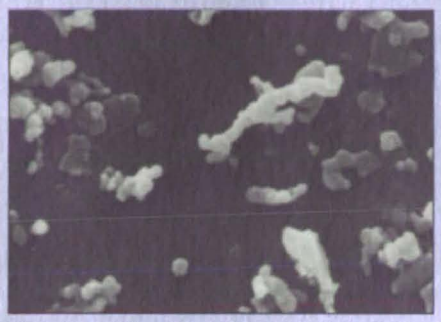
The separation between the orifices does not have to be precisely half a wavelength; a substantial error is acceptable. The acoustical technique itself can be used to determine the correct separation by trial and error, or the separation can be determined theoretically. The acoustical technique is superior to hot-wire anemometry (the invasive technique ordinarily used in measurements of



A **Microphone Mounted Below the Surface** detects pressure waves indicative of instabilities in a laminar flow. The microphone is relatively insensitive to long-wavelength background noise.

INCO SPECIALTY POWDER PRODUCTS RESEARCH AND DEVELOPMENT... NEW PRODUCTS FOR NEW TECHNOLOGIES

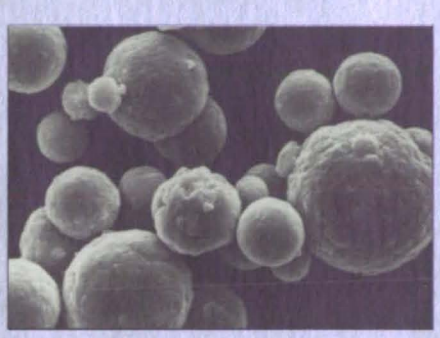
Victor Ettel, Director of Battery Powder Research, Sheridan Park, Mississauga, Ontario, Canada. His job is to find new uses for carbonyl technology.



UFP, Ultra Fine Powder

Eurof Rees, Pilot Plant Superintendent, Clydach Nickel Refinery, Wales, U.K. Eurof has been involved in carbonyl coating of substrates for more than twenty years.

Frank Heck, Technical Director, Novamet Specialty Products Corp. Wyckoff, New Jersey. Frank is always looking for new ways to produce a better powder.



4SP Spherical Powder

George Tyroler, Technical Superintendent, Copper Cliff Refinery, Sudbury, Canada. George likes working on the edge of developing nickel powder products.

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4SP Spherical Powder. Completely spherical and smooth in shape. Particle sizes of 8-9 microns. It has the potential to increase strength of P/M steel parts compared to other nickel powders. The particle shape presents opportunities for metal injection molding.

INTERNATIONAL RESEARCH GROUP

INCO Specialty Powder Products is conducting research and development at the Novamet Specialty Products Corp. in the US, at the Clydach Refinery in Wales, UK, and Sheridan Park Corporate Laboratory and Copper Cliff Refinery in Ontario, Canada. We are fortunate to have some of the leading powder technology researchers on our staff.

For more information write INCO Specialty Powder Products, Dept. 3-90, Park 80 West-Plaza Two, Saddle Brook, NJ 07662

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15/Fl Wilson House, 19-27 Wyndham Street Central, Hong Kong

Circle Reader Action No. 542

boundary-layer flows) in several respects:

- The microphone detects the waves more easily;
- The microphone is rugged, whereas hot-wire probes are fragile;
- It is not necessary to scan across the boundary layer to find the maximum wave amplitude, as it is with a hot-wire probe;
- The microphone is cheap, whereas the electronic control unit of a hot-wire anemometer is expensive;
- Because the technique is noninvasive, many microphones can be installed and operated simultaneously to determine the propagation of waves over a broad area.

This work was done by James M. Kendall of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 147 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Headquarters-JPL [see page 24]. Refer to NPO-17479.

Monolithic Unidirectional Planar Ring Laser

Operation would be based on induced birefringence of the stressed laser medium.

Langley Research Center, Hampton, Virginia

Unidirectional operation of a ring laser is made possible by polarization-dependent differential loss induced by some combination of reciprocal and nonreciprocal polarization effects. For each direction of propagation around a ring, there are two possible eigenpolarizations. Since there are two directions of propagation, there are four eigenpolarizations to consider. According to one concept for a unidirectional ring laser, the eigenpolarizations would be sorted according to the round-trip loss associated with each one. In general, the four eigenpolarizations can have four different associated losses. Considering only the low-loss eigenpolarization for each direction of propagation, unidirectional operation of the laser becomes possible if the difference between the losses of the low-loss eigenpolarizations for the two directions of propagation is made sufficiently large.

This concept arises from the theoretical analysis of the monolithic unidirectional nonplanar ring laser described in the preceding article, "Monolithic Unidirectional Nonplanar Ring Laser" (LAR-14146). The analysis proves that, for an optically isotropic laser medium, stable unidirectional operation of a monolithic ring laser is possible only if the ring path is nonplanar and a sufficiently large magnetic field is applied to the laser medium. The new concept circumvents the previous analysis by breaking the optical isotropy of the laser medium by applying stress.

To establish unidirectional operation of a monolithic planar ring laser, there would be a three-bounce ring path in which two of the bounces would be total internal reflections and the third would be an oblique reflection from a multilayer dielectric-coated spherical surface. The multilayer mirror bounce would act as a partial polarizer, the principal axes of which would be parallel and perpendicular to the plane of incidence. An external magnetic field applied to the laser medium would cause nonreciprocal Faraday rotation for propagation along any segment of the optical path that is not perpendicular to the applied field.

With principal axes that are rotated with respect to those of the output coupler, stress would be applied to the laser medium. The stress would create birefringence in the previously optically isotropic medium. Since the axes of the stress would be rotated with respect to those of the output coupler, the medium would act as a reciprocal wave plate. For simplicity, if the laser medium were in the shape of a rod, the stress would be applied by squeezing the rod between diametrically opposite contact lines.

This concept provides the essential elements required to produce differential loss between the two directions of propagation. The reciprocal polarization effect would be produced by the induced birefringence of the stressed laser medium. The nonreciprocal polarization effect would be the Faraday rotation. The differential loss would be caused by the partial polarization that would occur upon reflection from the multilayer dielectric coating.

The frequency of the planar ring laser could be adjusted by varying the magnitude of the applied stress, the magnetic field, or both. The laser could also be tuned by varying the temperature of the laser medium. The concept applies to any initially optically isotropic material that has a nonzero Verdet constant, such as neodymium:yttrium aluminum garnet (Nd:YAG), neodymium:gadolinium gallium garnet (Nd:GGG), or Nd:glass. Since unidirectional lasers can have spectra narrower than those of bidirectional lasers, they could have significant potential for use in metrology and spectroscopy.

This work was done by Alan C. Nilsson and Robert L. Byer of Stanford University for **Langley Research Center**. *No further documentation is available.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Mr. Jon Sandelin
Office of Technology Licensing
Stanford University
857 Serra St., 2nd Floor
Stanford, CA 94305-6225

Refer to LAR-14045, volume and number of this NASA Tech Briefs *issue, and the page number.*

Monolithic Unidirectional Nonplanar Ring Laser

A design concept provides for narrow-linewidth operation in relatively inexpensive Nd:glass.

Langley Research Center, Hampton, Virginia

In typical previous work with a monolithic nonplanar ring laser, four reflecting surfaces defined the ring light path. A new design has six reflecting surfaces. With this design, the differential loss that is required to achieve unidirectional oscillation can be 100 times as great as with four reflecting surfaces.

Unidirectional oscillation occurs in a ring laser if there is a sufficiently large differential loss between the polarization eigenmodes of the two directions of propagation around the ring. The most important criterion for producing large differential loss is that the sum of the relative phase shifts produced by the total internal reflections must slightly exceed 180°. In a conventional design with four reflecting surfaces, it is impossible to satisfy this criterion for a laser material that has an index of refraction smaller than $\sqrt{3}$ because the index of refraction determines the upper limit of the amount of relative phase shift produced by a single total internal reflection.

Since most laser glasses have indices of refraction substantially smaller than $\sqrt{3}$, the new six-reflector geometry was conceived to design monolithic glass resonators with large differential loss, overcoming the index-of-refraction limitations

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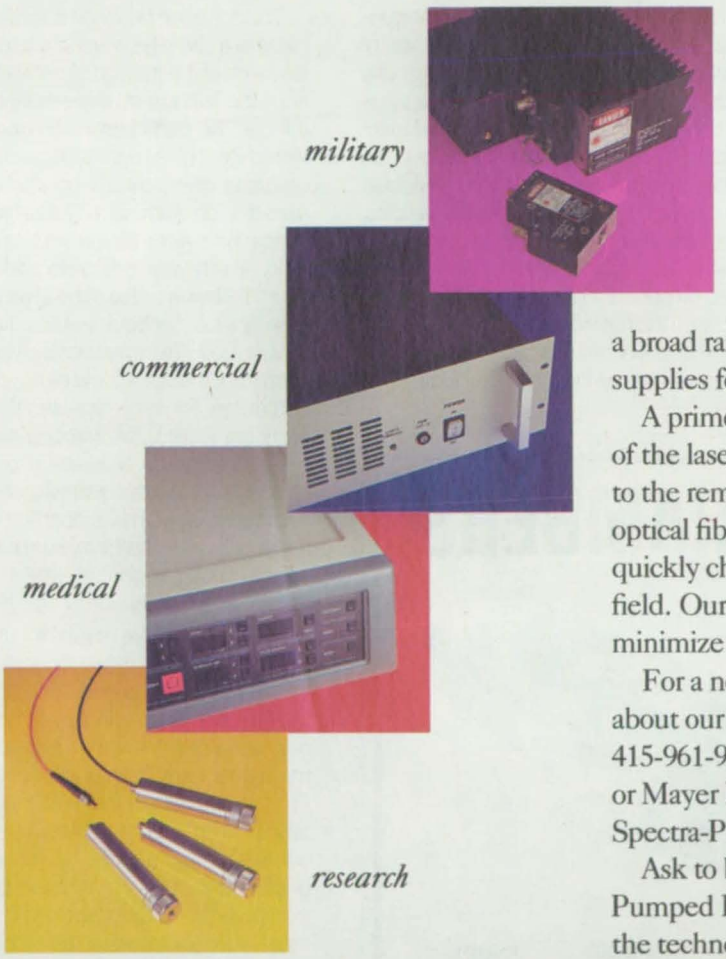

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associated with the four-reflection resonator. The new design calls for a monolithic ring laser with five total internal reflections and one reflection from a partially transmitting multilayer dielectric-coated output coupler. Preliminary analysis of the six-reflection resonator shows that the differential loss can be at least 100 times as great as the largest differential loss available in a four-reflection design, assuming that the same magnetic field is applied to each resonator. This design should enable unidirectional operation.

Laser glasses differ from such cystalline host media as yttrium aluminum garnet (YAG) in several important ways. For example, the intrinsic scatter and absorption loss in well-engineered laser glass promise to be several orders of magnitude lower than those of Nd:YAG. The implication of this difference is that the fundamental limit on the width of the spectral line of a free-running Nd:glass laser can be many orders of magnitude smaller than that of a comparable Nd:YAG laser. Narrow-linewidth Nd:glass master oscillators based on this design could find immediate applications as the seed lasers for large Nd:glass laser systems. The very-narrow-linewidth lasers made possible with this concept have potential applications in metrology and spectroscopy.

This work was done by Alan C. Nilsson and Robert L. Byer of Stanford University for **Langley Research Center**. *No further documentation is available.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Mr. Jon Sandelin
Office of Technology Licensing
Stanford University
857 Serra Street, 2d Floor
Stanford, CA 94305-6225

Refer to LAR-14146, volume and number of this NASA Tech Briefs *issue, and the page number.*

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Adhesion Between Particles and Surfaces in a Vacuum

Factors that could affect contamination are studied.

A report discusses an experimental study of the adhesion between several kinds of particles and solid surfaces. The purpose of this investigation was to extend the available data on the adhesion of contaminant particles; in particular, to contribute to an understanding of the ways in which acceleration can redistribute contaminant particles, thereby causing increases or decreases in contamination. The investigation was motivated by concern over the contamination of optical instruments resulting from the transfer of dust from nearby equipment during the launch of the Space Shuttle.

The adhesion between a surface and particles of a given type was measured via observation of the fraction of particles removed from the surface by acceleration in a centrifuge. The particle/surface combinations tested were glass beads on glass, road dust on glass, glass beads on aluminum, and road dust on aluminum. The particle/surface specimens were placed in the centrifuge tube, which was evacuated before it was spun. Tests were also done at ambient pressure; that is, without evacuating the centrifuge tube. The accelerations were calculated from the speed and dimensions of the centrifuge. For each type and size range of particles tested, the fraction removed by centrifugation as a function of size was matched via a least-squares best fit to a two-parameter log-normal probability distribution and to a related mathematical model of the acceleration (or, equivalently, the force of adhesion) as a function of size and density.

In comparing the results for glass beads on aluminum with those for glass beads on stainless steel in a previous study, the author drew the tentative conclusion that continuous acceleration could remove particles more effectively than brief impulses could. From the results of these experiments, the author concluded that glass beads did not adhere as well as dust did to either glass or aluminum, either at ambient pressure or in the vacuum. Dust appeared to adhere more strongly to glass than to aluminum, at both ambient pressure and in the vacuum. No statistical difference between the adhesions of glass beads or dust to either substrate at ambient pressure and in the vacuum was found. However, the dust adhered more weakly to glass at the intermediate pressure of 10 torr (1.3 kPa) than at the ambient pressures or in the high vacuum. This result was the only evidence for a dependence on pressure.

This work was done by Jack B. Barengoltz of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Particle Adhesion to Surfaces Under Vacuum," Circle 158 on the TSP Request Card.*
NPO-17743

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

$NbSe_3$ Cathodes for Li Rechargeable Cells

The electrochemical and physical characteristics of $NbSe_3$ are reported.

A report describes experimental studies involving the preparation, characterization, and measurements of the performance of $NbSe_3$, which is intended for use as cathode material in lithium rechargeable electrochemical cells. $NbSe_3$ has characteristics superior to those of other intercalating cathode materials, including high volumetric and gravimetric energy densities and the ability to sustain discharges at high rates.

The $NbSe_3$ was prepared by heating premixed stoichiometric amounts of Nb and Se powders at a temperature of 670 °C for 7 to 15 days. The $NbSe_3$ grows as long, hairlike fibers that intertwine to form a physically bonded and electrically conductive mat. Cathodes were made by packing $NbSe_3$ mats between Ni screens.

The $NbSe_3$ was examined by x-ray diffraction and scanning electron microscopy. Techniques used in the electrochemical evaluation included cyclic voltammetry, constant-current and constant-potential discharges, dc potentiometric scans, ac impedance, and ac voltammetry. The electrolyte for the electrochemical evaluation of the $NbSe_3$ was 1.5 M $LiAsF_6$ in 2-methyltetrahydrofuran.

From the electrochemical measurements it was concluded that $NbSe_3$ intercalates reversibly with 3 equivalents of Li at an efficiency of utilization of about 90 percent. The intercalation of lithium appears to occur at different closely spaced potentials between 1.8 and 1.5 V versus Li^+/Li. The kinetics of the reduction of $NbSe_3$ are essentially governed by the slow diffusion of Li ions inside the layered cathode. The dc kinetic parameters are the exchange-current density of 32 $\mu A/cm^2$ and the apparent-transfer coefficient of 0.21.

Constant-current, constant-potential, and ac impedance measurements suggest that the structure of $NbSe_3$ undergoes a beneficial change upon initial discharge, even though the cathode loses about 10 percent of its initial capacity to some irreversible intercalation. As a result of this apparent change, the nominal discharge voltage increases somewhat, leaving the energy density the same as, or slightly greater than, it was initially.

A physical model for the reduction of $NbSe_3$ is proposed: Li ions from the solution reach the channels of the $NbSe_3$, react, and are intercalated in the material. So long as enough vacant channels remain available to the Li ions in solution, the rate of reduction of $NbSe_3$ is governed only by the charge-transfer kinetics. Once the channels are filled, no further reduction can occur until the Li at the surface jumps deeper into the cathode material to the next available site. To maintain electroneutrality, the counter charge moves in the direction opposite that of the flow of Li^+ ions, thus making it appear as if the reduced layer of $NbSe_3$ moves deeper into the material, exposing unreduced $NbSe_3$ to the solution.

This work was done by Ratnakumar V. Bugga, Ching-Ion Ni, Salvador DiStefano, Robert B. Somoano, and C. Perry Bankston of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Studies on Niobium Triselenide Cathode Material for Lithium Rechargeable Cells," Circle 24 on the TSP Request Card.*
NPO-17491

Microstructure of a SiC/(Ti/V/Cr/Sn/Al) Composite

Techniques and results of metallographic analysis are reported.

A NASA technical memorandum reports on the analysis of a composite material made of SiC fibers in a matrix of 0.76 Ti/0.15 V/0.03 Cr/0.03 Sn/0.03 Al (parts by weight) alloy. The purposes of this study were to investigate the suitability of some

metallographic techniques for use on composite materials in general and to obtain information about the macrostructure and microstructure of this specific composite to provide guidance for experimental and theoretical studies of more advanced composites.

All specimens were sectioned with a 0.3-mm-thick diamond-impregnated wheel, then mounted in epoxy. The mounted specimens were ground flat by use of a resin-bonded diamond grinding disk and successively finer diamond grits in water. The ground specimens were lapped with diamond slurries, then polished with fine diamond (down to 0.5-μm diamond paste) to reveal the microstructure at the required resolution. Selected specimens were etched with an aqueous solution of nitric and hydrofluoric acids. Selected specimens were coated with an interference layer to facilitate differentiation between phases.

Specimens that had been polished, polished and etched, and polished and interference-layered were examined by scanning electron microscopy at accelerating potentials of 15 and 20 kV. Elemental x-ray analysis involving spot modes, analog scan lines, and dot maps was performed as needed. Specimens for transmission electron microscopy were prepared by a process of diamond-wheel sectioning, grinding, dimpling with diamond slurries, and ion-beam milling. These specimens were then viewed in a transmission electron microscope at 120 kV.

The examination of the specimens led to the following conclusions about the structure of the composite:

- The distribution of SiC fibers in the matrix as viewed in a section perpendicular to the axes of the fibers approximated a rectangular array with average center-to-center distances of 220 μm within a row and 350 μm between rows. Separations within any row varied greatly. Out of 1,600 fibers, 6.3 percent touched and always contained coating cracks at the points of tangency. The volume fraction of fibers was measured as 36 percent.
- The grains within the matrix were generally orthorhombic with an average dimension of 200 μm parallel to the fibers and with lengths of 110 and 350 μm in the transverse plane.
- A series of small, more-equiaxed grains of diameters in the range of 10 to 80 μm surrounded the fibers.
- Titanium wires were woven around the fibers to keep them parallel during fabrication. Upon consolidation, the wires formed particles high in Ti and C (probably TiC). Between the particles was a lamellar structure believed to be α- and β-Ti. The matrix surrounding this woven structure appeared to have transformed to the solute-lean β'-phase.
- The fibers were made from carbon cores, upon which a pyrolytic carbon coating had been deposited. SiC was built up on this core by chemical-vapor deposition. Small equiaxed grains were observed adjacent to the pyrolytic coating. The SiC grains had become elongated as the diameters of fibers increased during deposition. The grains were heavily faulted.
- A carbon-rich coat was applied to the surfaces of the fibers. Four zones were identified within this coat. The composition and structure of each zone were identified.
- A reaction zone 0.10 to 0.35 μm thick formed at the interface between the matrix and the fiber. This zone consisted of very small crystallites, which were believed to be titanium carbides and titanium silicides.

This work was done by Bradley A. Lerch and David R. Hull of **Lewis Research Center** *and Todd A. Leonhardt of Sverdrup Technology, Inc. Further information may be found in NASA TM-100938 [N88-28095], "As-Received Microstructure of a SiC/Ti-15-3 Composite."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

LEW-14868

Polytetrafluoroethylene-Impregnated Anodization for Aluminum

Standard hard anodization gives better protection against corrosion than polytetrafluoroethylene-impregnated anodization does.

A technical memorandum describes experiments on the ability of two commercial coatings and of standard hard anodization to protect aluminum against corrosion. Both commercial coatings, Polylube and Tufram, are polytetrafluoroethylene-impregnated anodizations.

Disks of aluminum alloy 6061-T6 were coated with layers of either Polylube or Tufram 40-μm-thick. Disks were also hard-anodized by the Alumilite process and sealed in either boiling deionized water or a 1-percent solution of $Na_2Cr_2O_7$. The disks were exposed to solutions of 3.5 percent sodium chloride buffered to pH 5.5 and pH 9.5 at 25 °C. Both ac-impedance and dc-polarization-resistance methods were used to determine the rates and mechanisms of corrosion.

In all cases, corrosion was found to be more pronounced at pH 5.5 than at pH 9.5. Corrosion pits tended to heal at the higher pH, probably because corrosion products are less soluble at that value.

The standard hard-anodized coating was found to provide the greatest protection. The hard-anodized, water-sealed coating showed no pitting at pH 9.5. Neither did the hard-anodized, dichromate-sealed coating, although the corrosion currents of this coating were somewhat higher. A small amount of pitting occurred at pH 5.5 in both water-sealed and dichromate-sealed hard-anodized coatings, although they were otherwise in good condition.

Some cracking occurred in both polytetrafluoroethylene-impregnated anodized coatings at both pH levels. Tufram, in general, protected more than Polylube did. The greatest deterioration occurred in Polylube coatings at pH 5.5.

This work was done by Merlin D. Danford of **Marshall Space Flight Center**. *Further information may be found in NASA TM-100366 [N89-26079], "The Corrosion Protection of Aluminum by Various Anodizing Treatments."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
MFS-27229

Computer Programs

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COSMIC, NASA's Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

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Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Machinery

Systems Improved Numerical Fluids Analysis Code

A thermal-analysis computer program is augmented for simulation of active heat-transfer loops.

The Systems Improved Numerical Fluids Analysis Code, SINFAC, consists of additional routines added to the April, 1983, version of SINDA, a general thermal-analyzer program. The purpose of the additional routines is to provide for the mathematical modeling of active heat-transfer loops. The modeler can simulate the steady-state and pseudo-transient operations of 16 different components of heat-transfer loops, including radiators, evaporators, condensers, mechanical pumps, reservoirs, and many types of valves and fittings. In addition, the program contains a property-analysis routine that can be used to compute the thermodynamic properties of 20 different refrigerants.

SINFAC can simulate the response to transient boundary conditions. SINFAC was first developed as a method for computing the steady-state performances of two-phase systems. It was then modified using CNFRWD, the explicit time-integration scheme of SINDA, to accommodate transient thermal models. However, SINFAC cannot simulate pressure drops due to time-dependent fluid acceleration, transient boilout, or transient fill-up, except in the accumulator. SINFAC also requires the user to be familiar with SINDA.

The solution procedure used by SINFAC is similar to that which an engineer would use to solve the equations of a system manually. The solution to the equations of a system requires the determination of all of the outlet conditions of each component such as the flow rate, pressure, and enthalpy. To obtain these values, the user first estimates the inlet conditions to the first component of the system, then computes the

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outlet conditions from the data supplied by the manufacturer of the first component. The user then estimates the temperature at the outlet of the third component and computes the corresponding resistance to flow posed by the second component. With this flow resistance of the second component, the user computes the conditions downstream; namely, the inlet conditions of the third component. The computations follow for the rest of the system, back to the first component.

On the first pass, the user finds that the calculated outlet conditions of the last component do not match the estimated inlet conditions of the first. The user then modifies the estimated inlet conditions of the first component in an attempt to match the calculated values. The values estimated by the user are called "state variables." The differences between the values estimated by the user and the calculated values are called the "error variables." The procedure systematically changes the state variables until all of the error variables are less than the iteration limits specified by the user.

The automated solution procedure, which follows the foregoing logic, is referred to as SCX. It consists of two phases: the systems phase and the controller phase. The "X" is to imply "experimental." SCX computes each next set of state variables in the two phases. In the first (systems) phase, SCX fixes the controller positions and modifies the other state variables by the Newton-Raphson method. Once the Newton-Raphson method has solved the problem for the fixed controller positions, SCX, in the controller phase, next calculates new controller positions based on Newton's method while treating each sensor/controller pair independently but allowing all to change in one iteration.

SINFAC is available by license for a period of 10 years to approved licensees. The licensed program product includes the source code for the additional routines to SINDA, the SINDA object code, command procedures, sample data, and supporting documentation. Additional documentation may be purchased. SINFAC was created for use on a DEC VAX under VMS. Source code is written in FORTRAN 77, requires 180K of memory, and should be fully transportable. The program was developed in 1988.

This program was written by F. A. Costello for **Goddard Space Flight Center**. *For further information, Circle 20 on the TSP Request Card.*
GSC-13231

Mathematics and Information Sciences

Schedule-Report-Generator Computer Program

Engineering managers can monitor scheduled tasks assigned to staff members.

The Schedule Organizer (SO) (COSMIC Program MSC-21525), Schedule Tracker (ST) (COSMIC program MSC-21526), and Schedule Report Generator (SRG) are computer programs that manipulate database files in ways that are advantageous in scheduling. Originally designed for the Space Shuttle flight schedule, the program can be easily modified for other scheduling situations.

Schedule Organizer provides a simple method for generating distribution lists. These distribution lists contain readers' names for each task schedule defined by the input files. Schedule Tracker provides an effective method for tracking tasks that are "past due" and/or "near term." ST generates reports for each responsible staff member who has one or more assigned tasks that fall within the two listed categories. This enables an engineering manager to monitor tasks assigned to staff by running ST on a weekly basis. ST lists only reports on tasks that have become past due or are scheduled for completion in the near future.

Schedule Report Generator provides a simple method for generating periodic schedule reports. SRG enables an engineering manager to monitor tasks assigned to staff members on a weekly basis. SRG sorts three types of reports by use of one or more data fields as sorting keys. One type is sorted by use of the calendar year as the primary key and the end date as the secondary key. Another type is sorted by flight number. A third type of report, Waterfall plots, is also generated by SRG by use of the end date as the sorting key.

SRG requires as input a single file or two concatenated files that contain up to 400 single line entries. The user constructs the input file by using the LSE editor VAX utility prior to the execution of the program. The user can modify the current functional description text lines just displayed.

ST and SRG use the same data-base file as input. The common data-base file has a maximum number of 400 entries. The time span of all three programs is 19 months. Both of these maximum numbers can be modified by the user. SRG can be purchased separately or in a package (COSMIC program COS-10021) containing SO, ST, and SRG. SRG requires the VMS Operating System on a DEC VAX computer and was written in PL/1 and DEC Command Language (DCL). SRG was developed in 1984.

This program was written by Fernando F. Collazo of Rockwell International Corp. for **Johnson Space Flight Center.** *For further information, Circle 83 on the TSP Request Card. MSC-21527*

Schedule-Organizer Computer Program

This program provides a simple method for the generation of distribution lists.

The Schedule Organizer (SO), Schedule Tracker (ST) (COSMIC program MSC-21526), and Schedule Report Generator (SRG) (COSMIC program MSC-21527) are computer programs that manipulate data-base files in ways that are advantageous in scheduling. Originally designed for the Space Shuttle flight schedule, the program can be easily modified for other scheduling situations.

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SO contains a primary menu that is displayed at the beginning of the program. The menu provides the following options: to write input files to an output distribution file, to change a schedule-title field and/or distribution-list field, to browse through the schedule and input names file for requested schedule numbers, to create an input names file and a schedule-titles file, and to delete input schedule titles and associated names. SO provides a choice of two input files. One file holds 25 groups of up to 25 names for each group. The other file holds 25 records. Each 60-character-long record holds a task-schedule title or it is a blank entry.

SO creates three output files. One holds the formatted list of schedule titles for printout. Another file holds the formatted distribution list for printout; there is one for each input names file schedule group. The third output file holds the schedule title of the last schedule-title file deleted by the user.

The time span of SO is 19 months. This parameter can be modified by the user. The SO program requires the VMS Operating System on a DEC VAX computer and was written in PL/1 and DEC Command Language (DCL). SO can be purchased separately or in a package (COSMIC program COS-10021) containing SO, ST, and SRG. SO was developed in 1985.

This program was written by Fernando F. Collazo of Rockwell International Corp. for **Johnson Space Flight Center**. *For further information, Circle 84 on the TSP Request Card.*
MSC-21525

Schedule-Tracker Computer Program

This program generates reports on tasks that should be completed.

The Schedule Organizer (SO) (COSMIC program MSC-21525) Schedule Tracker (ST), and Schedule Report Generator (SRG) (COSMIC program MSC-21527) are computer programs that manipulate data-base files in ways that are advantageous in scheduling. Originally designed for the Space Shuttle flight schedule, the program can be easily modified for other scheduling situations.

Schedule Organizer provides a simple method for generating distribution lists. These distribution lists contain readers' names for each task schedule defined by the input files. Schedule Tracker provides an effective method for tracking tasks that are "past due" and/or "near term." ST generates reports for each responsible staff member who has one or more assigned tasks that fall within the two listed categories. This enables an engineering manager to monitor tasks assigned to staff by running ST on a weekly basis. ST lists only reports on tasks that have become past due or are scheduled for completion in the near future. Schedule Report Generator provides a simple method for generating periodic schedule reports. SRG enables an engineering manager to monitor tasks assigned to staff members on a weekly basis.

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This program was written by Fernando F. Collazo of Rockwell International Corp. for **Johnson Space Flight Center**. *For further information, Circle 82 on the TSP Request Card.*
MSC-21526

Documenting Software Automatically

The often neglected chore of documenting software is simplified.

The Automated Software Documentation Utility is a package of software designed to provide automated drafts of manual documentation directly from compatible C source code in the UNIX environment. These programs were designed to simplify and streamline the crucial yet often neglected chore of documentation of programs. Basic design goals were to make maximum use of the standard UNIX environment and to ensure that there were as few constraints on the source code as possible. The implementation chosen was to generate MAN macro format text files by

parsing input source code. To provide some flexibility as to the formats of the target documentation, the process was divided between two programs: a parser, CSTRIP, and a text reformatter, TXMAN.

The CSTRIP program parses C source code from specified files and extracts top-level information from declarations and comments. The output is standard and nominally consists of the sections NAME, SYNOPSIS, and DESCRIPTION. The NAME section is a list of all global identifiers. These are basically the identifiers that may be accessible to the linker. Identifiers are considered global if they are function or variable names defined in the file without static storage class identifiers. The SYNOPSIS section gives the types and arguments for all global identifiers. The DESCRIPTION section contains comments that occur in a global context. Commentary text is considered to have global context if it is associated with a global identifier or argument or is separated from nonglobal contexts. The output produced from CSTRIP is in a simple free-format text language.

The program TXMAN provides an interface between the output of CSTRIP and the standard UNIX text processor NROFF by reformating the text to the MAN macro format used by the UNIX MAN command. It also sorts intermingled manual sections and provides easier access to features like "pagesize" and "linelength". Accordingly, one might prefer to use TXMAN rather than to use the MAN macros directly.

The Automated Software Documentation Utility was written in C and Unix Shell for execution on an HP 9000 series 500 computer under the HP-UX release 5.0 operating system. It has a central-memory requirement of approximately 57 Kbytes. This utility was developed in 1986.

This program was written by L. A. Pieniazek of TRW, Inc., for **Johnson Space Center**. *For further information, Circle 16 on the TSP Request Card.*
MSC-21297

Generating Semi-Markov Models Automatically

The ASSIST program facilitates analysis of the behavior of a fault-tolerant computer.

Because of their flexibility, semi-Markov models can be used to describe the fault behavior of any fault-tolerant computer architecture. However, it is impractical to generate manually the large semi-Markov models needed to describe the behavior of a large, complex system accurately. For this reason the Abstract Semi-Markov Specification Interface to the SURE Tool (ASSIST) program was developed to generate a semi-Markov model automatically

from a description in an abstract, high-level language. ASSIST reads an input file that describes the failure behavior of a system in an abstract language and generates a Markov model in the format needed for input to the Semi-Markov Unreliability Range Evaluator (SURE) program (COSMIC program number LAR-13789).

A Markov model represents a number of states of the system and transitions between those states. Each state in the model represents a possible state of the system in terms of which components have failed, which ones have been removed, etc. Within ASSIST, each state is defined by a state vector, each element of which takes on an integral value within a defined range. An element can represent any meaningful characteristic, such as the number of working components of one type in the system or the number of faulty components of another type in use.

A statement that represents a transition between states in the model has three parts: a condition expression, a destination expression, and a rate expression. The first expression is a Boolean expression that describes the state-space-variable values of states for which the transition is valid. The second expression defines the destination state for the transition in terms of state-space-variable values. The third expression defines the distribution of elapsed time for the transition.

The mathematical approach chosen to solve a reliability problem may vary with the size and nature of the problem. Although different solution techniques are utilized in different programs, it is possible to have a common input language. The Systems Validation Methods group at NASA Langley Research Center has created a set of programs that form the basis for a "reliability analysis" workstation. The components are the following: the SURE reliability-analysis program; the PAWS/STEM reliability-analysis programs (COSMIC program number LAR-14165) based upon the SURE input language; and ASSIST as the preprocessor to SURE, PAWS, and STEM.

ASSIST is written in PASCAL for interactive execution and has been implemented on a DEC VAX computer under VMS 4.7 with a virtual-memory requirement of approximately 88K of 8-bit bytes. ASSIST was developed in 1986.

This program was written by Sally C. Johnson of **Langley Research Center**. *For further information, Circle 8 on the TSP Request Card.*
LAR-14193

XTRN — Automatic Code Generator for C Header Files

This program generates "extern" declarations for all globally visible identifiers.

The computer program XTRN, Automatic Code Generator for C Header Files, generates "extern" declarations for all globally visible identifiers contained in input C-language code. Most C-language programs consist of separately compiled files that are linked together to form the executables. In general, when one file uses a variable or function defined in another file, it is necessary to use an "extern" declaration to provide proper type information for the identifier. In the usual C programming environment, such "extern" declarations are coded manually. This is tedious and can lead to error for large packages. XTRN generates external declarations by parsing the input text according to a syntax derived from C. This automatically provides consistent and up-to-date "extern" declarations and alleviates the tedium and errors involved in the manual approach.

XTRN was designed to operate as a text filter that accepts valid C code as input and generates "extern" declarations for variable and function identifiers that are visible outside the given source file. Each declaration is followed by a comment containing the name of the file in which the identifier occurs. The XTRN program parses the in-

put text according to a syntax derived from Kernighan-and-Ritchie C. This syntax was designed only for recognition of text that belongs in "extern" declarations. It does not implement the full C grammar.

Basically, XTRN parses only the top-level declarations in the input code. Since all text contained within curly braces is private to the file, it is ignored. Similarly, all preprocessor directives are assumed private and also ignored. In parsing the top-level declarations, XTRN attempts to determine the need for text tokens. It discards a token as soon as it is clear that the token is not needed in an external declaration.

XTRN does not parse variable types beyond recognizing whether a token is a type specifier and should be included in the "extern" declaration. It assumes "int" as the default type and "global" as the default storage type.

XTRN is written in C and Unix Shell for execution on an HP 9000 series 500 computer under the HP-UX release 5.0 operating system. It has a central-memory requirement of 57 Kbytes. XTRN was developed in 1986.

This program was written by Lester A. Pieniazek of TRW, Inc., for **Johnson Space Center**. *For further information, Circle 129 on the TSP Request Card.*
MSC-21298

Window Utility System Program

This program provides pull-down menus and multiple window displays at minimal cost.

The Window Utility System computer program provides a full-featured screen-management windowing software facility that can be incorporated easily into user application programs. It was developed to provide a more pleasing user interface for CLIPS, the C-Language Integrated Production System expert-system-development shell program. The Window Utility System program can also be used with many other application programs in the VAX/VMS language.

The system addresses the problem of providing pulldown menus and multiple windows at minimal cost in terms of executable image size and run-time performance. Most of these savings result from scaling the visible portions of application windows to a fixed screen size, with only the most-recently-displayed window visible. This results in a "stack" of windows from which the application programmer can make the desired window visible.

The application programmer can define pulldown menu windows that are opened

by pressing the corresponding "PF" key. Once the window is opened, options are selected by positioning the cursor over the desired entry, then pressing "RETURN." Once a menu option has been selected, the application programmer has full control over how that option is to be handled.

Data-entry forms provide for formatted display and update on the terminal screen. The application programmer designs the screen layout of the data fields, including the name and width of each field along with an assortment of valid criteria. Validation criteria can include the type of data, ability to update, help text, and an optional list of valid values for the field.

Terminal keys are used to position the cursor. The application programmer can design forms that do not completely fit the available screen space. To gain access to these fields, the Window Utility System automatically scrolls through the form whenever an attempt is made to tab beyond the last displayed field or backspace above the first field displayed.

The Window Utility System has been implemented on a DEC VAX computer operating under VMS 4.7 using terminals that support the DEC Special Graphics Character set (i.e., VT100-compatible). It was written in VAX C and uses the Curses Screen Management Functions and Macros. The Window Utility System has a virtual-memory requirement of approximately 88K of 8-bit bytes. It was developed in 1988.

This program was written by Eric G. Cooper of Planning Research Corp. of **Langley Research Center**. *For further information, Circle 85 on the TSP Request Card.*

LAR-13993

S-Chart — Scheduling-Chart Program

An easy-to-use program turns out time-line graphics of high quality.

The Schedule Chart Program (S-Chart) produces quickly, through an array of simple menu choices, high-quality Gantt-type scheduling and production time-line charts with minimal data-entry requirements. The software produces high-quality charts (20-, 40-, and 80-day options) in 10 to 20 minutes, including startup, entry of data, and printing. Reprints take less than 1 minute. Some of the more significant features are as follows: speed and ease of use with menu-driven selections from start to finish; storage and catalogs of all sets of data for rapid access and manipulation; compact program to permit storage of dozens of sets of data on the program disk; and creation of ASCII text files of graphs for rapid printing. The final product of the plotting routine is an extended ASCII character file, which shows the scheduled and actual work dates of the events. This file may be printed from the program or from DOS, or imported to a word processor for customizing.

S-Chart is not intended to take the place of commercial scheduling/project-management software. It is, however, a simple, somewhat limited Gantt-chart-plotting and scheduling/tracking program with an emphasis on the straightforward entry of data. There is no complex building of relationships between the scheduled events. Dates are entered as dates, not as algebraic functions.

All the files of S-Chart, except for the graph picture and the stand-alone executable, were written in a code that is 100 percent compatible with dBASE III. The executable was created with CLIPPER, and the graph picture files are written in ASCII code. S-Chart was implemented on a IBM PC-series computer under DOS and requires 215K bytes of memory. The program was developed in 1988.

This program was written by Eric R. Klinkner of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 6 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-29531.

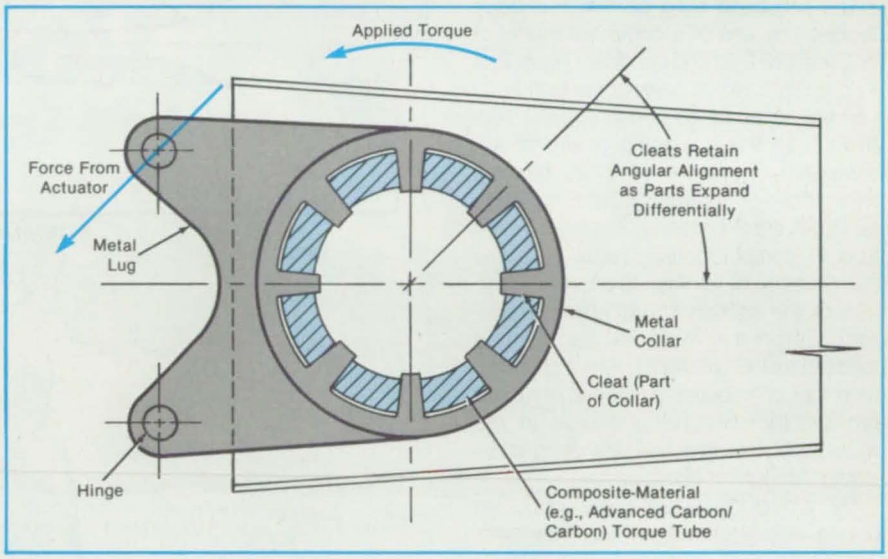
Mechanics

Low-Thermal-Stress Structural Joints for Dissimilar Materials

Such joints accommodate differential thermal growth between parts of dissimilar materials.

Langley Research Center, Hampton, Virginia

There is a need for structural joints that can transmit large loads between dissimilar materials and that can be used over a broad range of temperatures without introducing large thermal stresses. For example, control surfaces for hypersonic aircraft require the transmission of large torque loads from hot aerodynamic surfaces to relatively cool wing structures. The joint systems of such control surfaces must ensure fixed attachment points while permitting differential growth at joints between parts made of dissimilar materials. When design techniques appropriate to conventional low-temperature structures are applied to such control surfaces, they result in large thermal stresses or the use of relatively-large-diameter fasteners, high attachment/hole stresses, and large differential movements between parts. These results, in turn, give rise to the need for a complex structural arrangement for the redistribution of loads through the vehicles or components.



Cleats Retain Angular Alignment and Remain Radially Convergent through the center as parts expand differentially. Thus, all cleats become loaded equally.

A structural joint has been developed for the attachment of a hypersonic control surface to an aircraft wing structure. The joint can transmit large torque loads from the composite control surface and torque tube (see figure) to the wing structure through a metallic attachment lug and collar. The torque load is transmitted from the tube to the collar by a series of radially oriented cleats. The bearing surfaces of the cleats are in a plane passing through the centerline of the torque tube.

Heating the system causes only radial growth of both the tube and the collar. Thus, even though the torque tube and the collar may have different coefficients of thermal expansion, differential thermal growth between the tube and the collar is in a radial direction and does not cause high thermal stresses or a loose joint. Provided that the materials are isotropic, the joint does not have any thermal stresses when it is uniformly heated or cooled. If the materials have different coefficients of thermal expansion in the in-plane and through-the-thickness directions, some thermal stresses may be produced by uniform heating or cooling of the joint, but the thermal stresses should be low.

This concept has potential for application to high-temperature structural joints associated with hypervelocity vehicles; for example, control surfaces, wing-to-fuselage joints and engine mounts of the National Aerospace Plane and planetary entry vehicles. Of particular interest are highly loaded joints between dissimilar materials that are expected to experience high temperatures.

This work was done by Edward C. Matza of LTV Corp. for **Langley Research Center**. *No further documentation is available.*
LAR-14138

Preventing Ventilation on Sailboard Skegs

Significant reductions in drag, combined with prevention of ventilation, would contribute to high performance.

Langley Research Center, Hampton, Virginia

A design effort has been undertaken to solve the spinout problem that plagues high-performance sailboards. Spinout is characterized by the sudden loss of lateral lift on the sailboard skeg. The sailboard skeg is a vertical fin on the bottom of a sailboard hull (see figure). It is a lift-producing device used to maintain equilibrium while the hull is underway by counterbalancing the lateral component of the sail force. Ventilation is a common phenomenon that drastically reduces the amount of lift produced by the sailboard

skeg. When ventilation occurs, the resulting unbalanced lateral sail force causes the sailboard hull to slide sideways.

Three conditions are required for ventilation: first, there must be a low-momentum space formed by boundary-layer separation; second, the separated region must be at subambient pressure; third, there must be atmospheric air in contact with this separated, low-pressure region. If all three conditions are met, air displaces the water on the low-pressure side of the sailboard skeg, destroying the skeg lift. The disadvantage of all previous methods for preventing ventilation is the higher drag associated with the generation of a vortex or turbulent flow. A proposed direct solution to this skeg-ventilation problem would significantly decrease the skeg drag.

The proposed skeg section has been designed by use of a computer model of the pressure field and boundary layer. This skeg section would prevent ventilation by maintaining attached boundary-layer flow throughout the operating environment. Computed drags are 17 to 29 percent below those of commonly used symmetrical NACA airfoil sections. The large reductions in computed drag result from the maintenance of laminar flow over 62 percent of the section chord while the sailboard is on the most-frequently-used points of sail. Cavitation, another phenomenon that contributes to spinout, would be avoided by preventing valleys in the pressure distribution while the skeg is operated throughout its range.

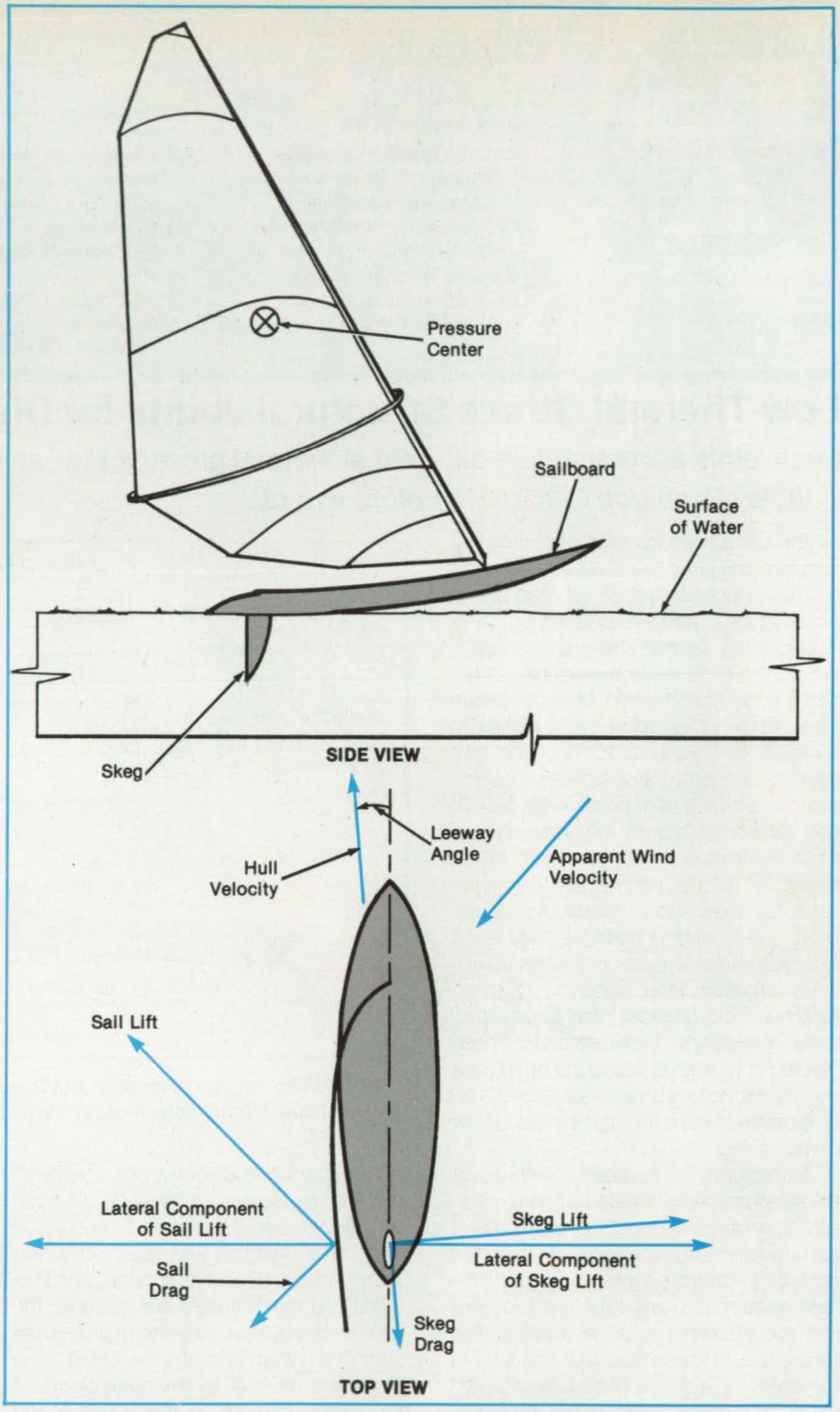
This type of foil section is also conducive to long lengths of laminar flow. The lower skin-friction drag associated with laminar flow and the lower pressure drag associated with attached flow are expected to result in lower overall drag, with consequent large improvements in performance.

This work was done by Richard A. Caldwell of George Washington University for **Langley Research Center**. *No further documentation is available.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Richard A. Caldwell
President, Race Technology, Inc.
2280 Avocado Ave., No. 11
Melbourne, FL. 32935

Refer to LAR-14008, volume and number of this NASA Tech Briefs *issue, and the page number.*



Skeg Ventilation Causes Unbalanced Lateral Forces on the sailboard, resulting in spinout.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Predictions of Drag in Viscous Transonic Flow

Results from the Viscous Transonic Airfoil Workshop are presented.

A NASA technical memorandum summarizes the results of computations of viscous, transonic flow reported at the Viscous Transonic Airfoil Workshop held in January, 1987. The results are reexamined and analyzed with special emphasis on drag. They are compared with each other and with data from experiments. Test cases include attached and separated transonic flows about a NACA 0012 airfoil. A total of 23 sets of numerical results from 15 different groups of authors are included.

The methods of computation used by the various authors vary from momentum-integral boundary-layer methods coupled with transonic potential inviscid codes to full Navier–Stokes methods. The majority

of methods (a total of 16) utilize the Navier–Stokes equations. This suggests a strong trend toward the Navier–Stokes formulation, even though it can be computationally expensive. The remaining formulations are split between several categories: two are Euler/boundary-layer methods, and five are potential/boundary-layer methods. The boundary-layer methods are divided between the momentum-integral approach and the full boundary-layer-equation approach.

The computed and measured data are presented as graphs showing the coefficients of pressure as functions of position on the upper and lower surfaces of the airfoil, coefficients of lift as functions of the angle of attack and the coefficient of drag, coefficients of drag as functions of the free-stream mach number, the derivative of the coefficient of lift with respect to the angle of attack as a function of the free-stream mach number, and the effect of grid refinement on the computed coefficient of drag.

The author draws the following conclusions: Methods for the computation of viscous, transonic, attached flows about airfoils have reached a sophisticated level of development. Most methods are capable of producing valuable results in the design environment, including the prediction of lift to within ±3 percent and drag to within ±5 percent. Other computed flow field data, including velocity boundary-layer profiles and skin-friction distributions, are in good agreement with each other and with experiment. Levels of scatter in computed and experimental zero-lift drag-rise characteristics are comparable, provided that proper levels of refinement of the computational grid are used.

On the other hand, methods for the computation of separated viscous, transonic flows about airfoils are not as well developed as are those for attached flows. This is largely due to the lack of accurate mathematical modeling of turbulence in regions of separated flow. Inadequacies in turbulence models are the most important physical-model errors associated with the results contained in the report. Despite this major defect, recent progress in this area suggests hope for the future.

This work was done by Terry L. Holst of **Ames Research Center**. *Further information may be found in NASA TM-100095 [N88-22009], "Computational Fluid Dynamics Drag Prediction — Results from the Viscous Transonic Airfoil Workshop."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12252

Measurements of Shock-Separated Turbulent Boundary Layers

Data are tabulated to facilitate comparison with other measurements and computations.

A report documents surface and flow-field measurements of two- and three-dimensional, shock-separated, turbulent boundary layers. Each test case consisted of an axisymmetric boundary layer flowing over a 5.02-cm-diameter cylinder whose axis was aligned with the wind-tunnel axis. A 30°-half-angle conical flare, mounted on the cylinder 1 m downstream of the nose, compressed the boundary layer, resulting in a shock wave and separation. Inclining the flare axis at an angle (α) greater than zero to the cylinder axis created a three-dimensional interaction. The nominal test conditions included the following: a total pressure of 1.7 atm (172 kPa), a total temperature of 265 K, a free-stream mach number of 2.85, and a free-stream Reynolds number of 16 million per meter. The incoming boundary layer thickness was 1.1 cm.

Measurements were made for the axisymmetric case ($\alpha = 0$) and for two three-dimensional flows ($\alpha = 5°$ and 10°). Two-color laser Doppler velocimetry was used to obtain velocity-field data, while an array of surface taps on the cylinder and flares provided static pressures. Shadowgraphs and oil-flow patterns were used to visualize the shock interactions and surface flows, respectively.

For each of the three cases (α) studied, the report presents in tabular form pressure, mean velocity, and turbulence data obtained at several streamwise locations. Only data from the azimuthal plane of symmetry — where the mean azimuthal velocity is assumed to be zero — are presented. The report also shows the shock-interaction shadowgraph and oil-flow pattern for each angle. Finally, plotted profiles are given for pressures, velocities, Reynolds stresses, and turbulent kinetic energies.

This work was done by J. D. Brown, J. L. Brown, and M. I. Kussoy of **Ames Research Center**. *Further information may be found in NASA TM-101008 [N88-27519], "A Documentation of Two- and Three-Dimensional Shock-Separated Turbulent Boundary Layers."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12298

Dye Tracing of Flow on Forebody of Airplane

Results are similar to those of wind-tunnel oil flows.

A report describes experiments in which flows over the forebody of an F-18 airplane were visualized by emitting a liquid containing a dye from orifices on the forebody. In this method, the liquid flows along the body and evaporates, leaving behind lines of dye that mark the streamlines and can be photographed after the test flight. This method was used because it was desired to visualize the flow at high angles of attack, at which the F-18 becomes laterally unstable and at which it could, therefore, be unsafe to photograph a tracer flow from a nearby chase airplane.

Dye lines representing the separation and reattachment of vortexes were identified at angles of attack from 19° to 47°. The angles of flow along the surface at the 90° and 270° meridians showed excellent agreement with those of a previous experiment in which the flow along an ogive having an aspect ratio of 3.5 (a shape similar to that of the forebody) was visualized by the oil-flow method in a wind tunnel.

The locations of the lines of separation and reattachment on the forebody looked

qualitatively similar to those produced by the oil-flow method in a wind tunnel on a 16-percent-scale model of the F-18. However, the laminar-separation bubble and the boundary-layer transition that were seen on model were not evident on the real forebody after flight.

The locations of the lines of separation and reattachment on the real forebody agreed fairly well with those of the ogive experiment. The elliptical cross section of the forebody caused the primary lines of separation to move toward the leeward meridian. Within the range of angle of attack tested, the angle of attack had little effect on the positions of the lines of separation.

This work was done by David F. Fisher, of **Ames Research Center**, *David M. Richwine of PRC System Services, and Daniel W. Banks of* **Langley Research Center**. *Further information may be found in NASA TM-100436 [N88-21127], "Surface Flow Visualization of Separated Flows on the Forebody of an F-18 Aircraft and Wind-Tunnel Model."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12237

Passive Damping of Vibrations in Truss Structures

Damping can be enhanced by redistribution of shear strains in damping materials.

A report describes theoretical and experimental investigations of passive damping of vibrations in truss structures. Interest in passive damping has been revived by proposals to construct large trusses in outer space. The studies described here represent a fresh look at this old topic, with a focus on the use of viscoelastic materials to damp longitudinal vibrations in the tubular members of such structures.

A representative member of the type studied is an integral assembly of three components: an inner tube called the "tubular member," which is the main part of the overall member and is fastened to the rest of the truss structure at its ends; an intermediate layer of viscoelastic material on the outer surface of the tubular member; and an outer tube called the "constraining member," which constrains and shields the viscoelastic material. The constraining member and viscoelastic layer can be shorter than the tubular member.

The theoretical investigation began with the reformulation of the shear-lag analysis of a previous study. Parameters that govern the quasi-static-damping performance were investigated on the basis of elastic strain energy, energy dissipated in viscosity per unit cycle of vibration, and the resulting complex modulus of viscoelasticity. The analysis showed that damping can be enhanced by suitably redistributing shear strain in the viscoelastic material. One of the parameters — the length of the constraining member — was found to be a convenient design variable for enhancement of the damping performance.

For the experimental investigation, several different integral damping members 8.62 in. (21.9 cm) long were constructed. Each integral damping member consisted of an aluminum tubular member of 0.5-in. (12.7-mm) outside diameter and 0.02-in. (0.5-mm) wall thickness, either of two types of acrylic polymeric damping layer, and an aluminum or graphite/epoxy constraining member. In some cases, the constraining members were segmented. The members were tested in a six-bay truss structure at low vibrational frequency and low dynamic strain. The effects of the segmented constraining members on damping performances were investigated by measuring decays of vibrations of the truss structure. Some experiments and some additional analyses focused on the damping effectiveness of constraining members that were "elastically tailored" by design to enhance damping via the coupling of extension/twisting deformations into the viscoelastic layers.

In some specimens tested in the truss structure, the measured damping values were less than the predicted ones; the discrepancies were attributed to uncertainty regarding vibration-loss factors of materials and imperfections arising from fabrication. Members with graphite/epoxy constraining members exhibited extremely low and inconsistent damping, perhaps caused by interactions among different polymers in the viscoelastic materials or by weak bonding to the surfaces of the aluminum tubes.

In the additional analysis of integral members with elastically tailored constraining members, it was shown that the extension/twisting coupling of a tailored constraining member can introduce additional shear strain in the viscoelastic material in the tangential direction, but the concomitant reduction in axial stiffness reduces the axial shear strain by an amount that cannot be overcome by the gain in the tangential component. Therefore, the use of an elastically tailored constraining member is not beneficial.

This work was done by Gun-Shing Chen and Ben K. Wada of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Passive Damping for Space Structures," Circle 144 on the TSP Request Card.*
NPO-17609

Machinery

Hydromechanical Advanced Coal Excavator

Water-jet cutting would reduce coal dust and its hazards.

NASA's Jet Propulsion Laboratory, Pasadena, California

Roof falls, moving vehicles, coal dust, and methane combine to make coal mining an exceptionally hazardous occupation. The Jet Propulsion Laboratory under contract to the Department of Energy has designed an advanced coal mining system, which will reduce deaths and disabling injuries from these and other inherent hazards by up to 90 percent.

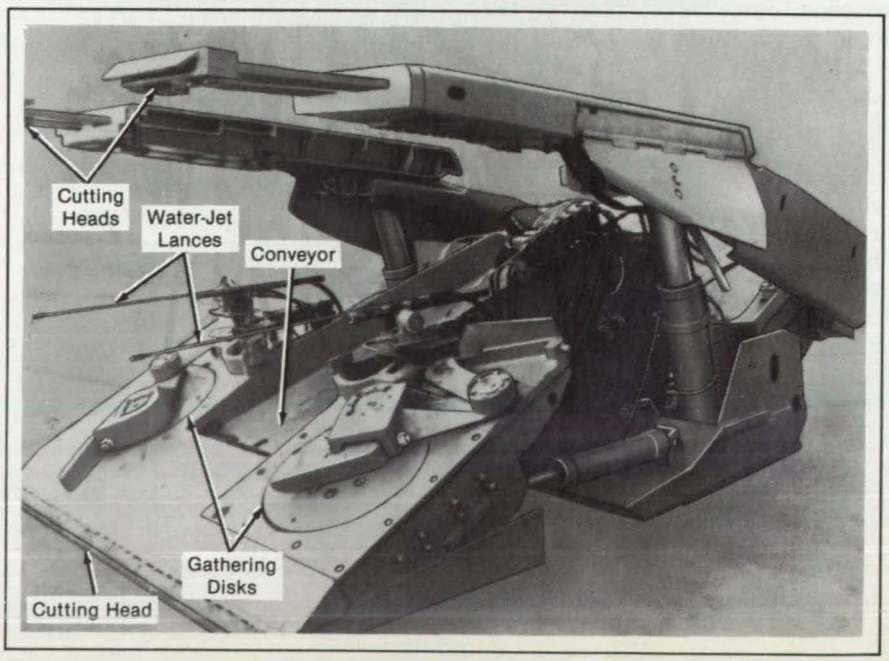
The advanced mining system utilizes a full-face, hydromechanical, continuous miner (see figure). High-pressure water jets operate in conjunction with wedge-shaped cutting heads to produce a cutting and wedging action, which exploits the weak tensile strength of coal. Very low levels of dust are generated during the process. In contrast conventional continuous miners utilize rotating cutting heads equipped with picks, which break the coal by means of compressive fracture. As a result, large quantities of dust are generated, posing both respiratory and explosion hazards.

As part of the process, water jets operating at 10,000 psi (70 MN/m^2) and 10 gal/min (6.3×10^{-4} m^3/s) cut a horizontal slot at the center of the coal roughly 2 to 4 ft (0.6 to 1.22 m) in depth, depending on the strength and structure of the coal. Wedge-shaped cutter heads are then forced into the slots, first at the floor and then at the roof. As the cutter heads advance, tensile forces break the coal into the horizontal slot at the center of the seam. Counterrotating gathering arms collect the coal and dump it onto a conveyor, which transports it behind the machine to be loaded onto a shuttle car, conveyor, or slurry-haulage system.

Roof support is provided for the entire entry, thus eliminating exposure to an unsupported roof and providing a safe environment for the operator and support personnel. Roof bolting activities occur directly behind the excavator as it advances into the coal seam.

A proof-of-concept prototype to demonstrate the water-jet cutting action has been developed at the University of Missouri, Rolla School of Mines. Advanced system prototype development is in progress.

This work was done by Jay M. Estus of Caltech, and David Summers of the University of Missouri, Rolla, for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 1 on the TSP Request Card.*
NPO-16442



The Advanced Coal Excavator uses high-pressure water-jet lances, one in each of the cutting heads and one in a movable lance, to make cuts across the top, bottom, and middle height, respectively, of the coal face. The wedge-shaped cutting heads advance into the lower and upper cuts in turn, thereby breaking the coal toward the middle cut. Thrust cylinders and walking pads advance the excavator toward the coal face.

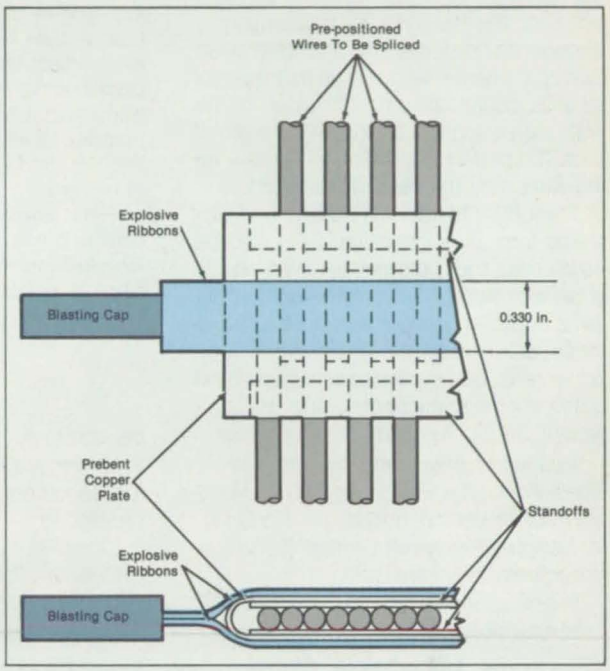
Fabrication Technology

Splicing Wires Permanently With Explosives

This technique produces superior, reliable splices.

Langley Research Center, Hampton, Virginia

An explosive joining process has been developed to splice wires by enclosing and metallurgically bonding the wires within copper sheets. Heretofore, in the manufacture of electrical equipment, small-diameter conductor wires have typically been spliced by brazing or soldering. Brazing has two disadvantages: the high temperatures locally anneal the wires and can cause wires to break, and the operators who perform the brazing operation must be highly skilled. Solder joints are not as strong as the wires. The joints made by the new explosive joining process exhibit many desirable characteristics, such as 100-percent conductivity and strength, no heat-induced annealing, no susceptibility to corrosion in contacts between dissimilar metals, and stability at high temperature. The new process could be used to join wires to terminals, as well as to splice wires.



Multistrand Conductors, as well as single wires, can be readily joined with the explosive technique.

The wires are spread in a plane in alternating fashion in the bundles to be joined (see figure). There is no limit on the number of wires and width. They are then slid into a U-shaped, prebent copper plate, wherein standoffs (any convenient material, such as tape) separate the wires from the plate. The ribbon explosive, which has previously been installed on the prebent plate and held in place by double-back tape, is then detonated by a blasting cap. The flat sections of the plate are driven into the wires in a high-velocity, angular impact, which effaces the oxide films from all surfaces to allow interatomic linkup of valence electrons.

Wires of two sizes [0.025 and 0.090 in. (0.64 and 2.3 mm)] were used with 0.030-in. (0.76-mm) copper plate, which was prebent to accommodate the different sizes and two 0.035-in. (0.89-mm) standoffs. The size of the ribbon explosive for the 0.025-in. wire was 20 grains/foot (4.2 g/m) and that for the 0.090-in wire was 30 grains/foot (6.4 g/m). The total amount of explosive used in this setup for a splice 1.5-in. (38-mm) wide is less than 1 g. After splicing, the excess copper sheet can be trimmed and the splice rolled for more convenient packaging.

The splice produced by this technique is more reliable than are brazed or soldered splices. This technique is directly applicable to the telecommunications industry, in which literally millions of small wires are spliced annually.

This work was done by Laurence J. Bement of **Langley Research Center** *and Anne C. Kushnick of PRC Kentron. For further information, Circle 149 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 24]. Refer to LAR-13825.

Making Lightweight Structures by Vapor Deposition

Complicated structures can be made stiff, strong, and light in weight.

Langley Research Center, Hampton, Virginia

A technique has been developed for the fabrication of stiff, strong, lightweight structures of silicon carbide or other materials by any of several deposition processes. The structures made by this method can have complicated shapes.

The fabrication of a structure by this method begins with the bonding together of thin ribs of graphite or other suitable material to make a core of honeycomb cells that have appropriate shapes. The core is mounted in the deposition chamber — possibly on a suitable substrate coated with a release agent. The SiC or other desired material is then deposited on the core by physical vapor deposition, chemical vapor deposition, evaporation, sputtering, or ion-beam deposition. The material is deposited to a thickness sufficient to ensure that the core is totally

coated.

The structure is unloaded from the deposition system and separated from the substrate. If necessary, the enclosed core material can be removed by drilling small holes in the walls of the structure, then burning, etching, or melting the core material away from the deposited overcoat.

When a vapor deposition technique is used to fabricate the structure, the flow is a stagnation flow governed by diffusion, yielding nonuniformity in the deposition along the cell depth. Nonuniformity can be minimized by providing holes in the walls of the honeycomb. These holes act as passages for the reagents to flow uniformly through the structure. Further, deposition occurs inside these holes, so that the material is connected on both sides of the wall, increasing the strength of the structure. The preferred location for holes is on the walls near the base of the structure.

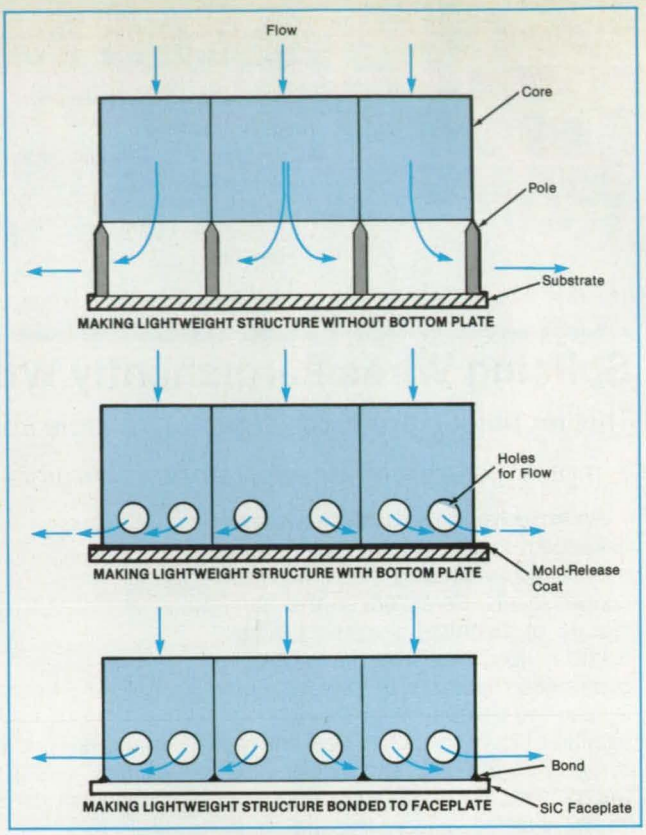
The ability to manufacture a complex shape from pure deposited SiC could be quite useful and could lead to new products in several fields. These lightweight structures could be used as backup structures for optical components, as structural components in automotive, aerospace, and outer space applications, and as lightweight parts of furniture for outer space.

This work was done by Jitendra S. Goela, Michael A. Pickering, and Raymond L. Taylor of Morton Thiokol, Inc./CVD Inc. for **Langley Research Center**. *No further documentation is available.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Gerald K. White, Esquire
Director, Patents and Trademarks
Morton Thiokol, Inc.
110 North Wacker Drive
Chicago, IL 60606–1560

Refer to LAR-14059, volume and number of this NASA Tech Briefs *issue, and the page number.*



Three Possible Configurations for Vapor Deposition illustrate the fabrication of lightweight structures by the new technique. If the structure is not to have a bottom plate, then the core can be mounted on a few poles attached to a substrate (top). If the structure is to have a bottom plate of deposited material, the core is placed on the substrate with a mold-release coat (middle). In an application like the fabrication of a lightweight mirror on an SiC faceplate, the core is bonded to the faceplate and the deposition is performed on both (bottom).

Zoom Vision System for Robotic Welding

Replacement of optical components to accommodate different geometries would be unnecessary.

Marshall Space Flight Center, Alabama

A rugged zoom lens subsystem has been proposed for use in the along-the-torch vision system of a robotic welder. The zoom subsystem would enable the system to adapt, via simple mechanical adjustments, to gas cups of different lengths, electrodes of different protrusions, and/or different distances between the end of the electrode and the workpiece. The zoom subsystem would make it unnecessary to change optical components to accommodate such changes in geometry, as one must do in the present system. It would be easy to calibrate with respect to the object in view.

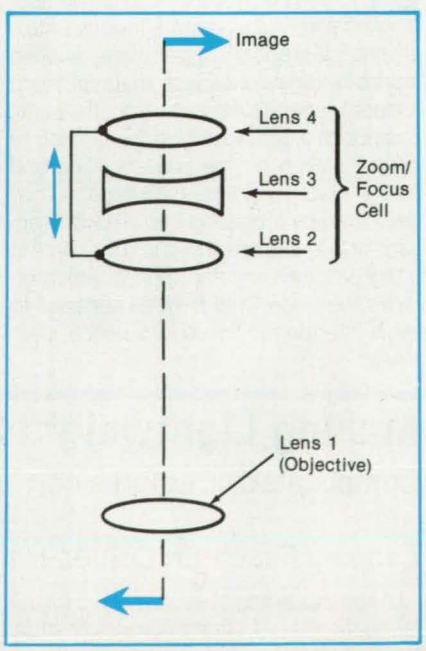
The zoom subsystem would be optically compensated. It would include an objective (lens 1) and a zoom/focus cell containing positive lenses 2 and 4 and negative lens 3 (see figure). The objective would collect the light from the welding scene being viewed; the zoom/focus subsystem would provide the variable magnification and focusing ability needed to adjust to the various welding setup geometries.

The fact that the zoom subsystem would be optically (rather than mechanically) compensated is important. Mechanical compensation necessitates the use of a complicated cam that provides the requisite nonlinear displacements between lenses. Optical compensation does not require such a cam — at least, not in this subsystem, in which any needed changes in magnification would be relatively small.

In a general optically compensated subsystem, two or more lenses are moved linearly, in tandem, with respect to other lenses, which remain fixed. In the proposed system, lenses 2 and 4 would be attached to each other and moved with respect to lens 3. This linear, tandem motion would provide the variable focus and variable magnification, including the ability to zoom in on a weld feature at higher magnification.

This work was done by Jeffrey L. Gilbert and Russell M. Hudyma of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-29712.



The **Zoom Optical Subsystem** would provide variable focus and variable magnification.

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TECHNOLOGY 2000 presents a unique opportunity to interact with these leaders, to develop contacts with potential R&D partners, and to discover what's directly ahead in a variety of high-tech fields.

Thousands of firms have picked up NASA's ideas and run with them, creating successful new products. Others have used space-based technology to hone their internal operations or improve their manufacturing systems. You too can benefit from this wealth of government-sponsored research. Join NASA, its major contractors, and other high-tech companies at **TECHNOLOGY 2000**, November 27-28, 1990.

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The **TECHNOLOGY 2000** program will feature over 100 presentations by top NASA researchers and industry leaders in the following areas:

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- ❖ Human Factors Engineering and Life Sciences
- ❖ Information and Data Management
- ❖ Manufacturing and Fabrication Technology
- ❖ Materials Science
- ❖ Optics and Communications
- ❖ Power, Energy, and Control Systems
- ❖ Robotics
- ❖ Sensors and Measurement Technology
- ❖ Superconductivity

TECHNOLOGY 2000 Program

Tuesday, November 27

Plenary Session I
8:30 a.m. - 11:00 a.m.

8:30 - Welcome: NASA Administrator Richard H. Truly
8:45 - Keynote Address: Dr. D. Allan Bromley, Assistant to the President for Science and Technology
9:15 - A View To The Future
Top NASA managers will describe three of NASA's primary missions: the Space Exploration Initiative, Mission To Planet Earth, and the National Aero-Space Plane Program.

Concurrent Technical Sessions
2:30 p.m. - 5:30 p.m.

Session A
Computer Technology and Software Engineering (Part 1)
The Virtual Environment Display System
Virtual Acoustics Displays
FAST: A Multi-Processed Environment for Visualization of Computational Fluid Dynamics
Hypercube Technology
The Hyperswitch Communication Network
Biological Neural Networks as Model Systems for Designing Parallel Processing Computers

Session B
Human Factors Engineering and Life Sciences (Part 1)
Biomedical Applications of NASA Technology
Direction-Discriminating Hearing Aid System
X-Ray Imaging Microscope for Cancer Research
Mechanical Response Tissue Analyzer for Estimating Bone Strength
Adaptation of NASA Technology for the Optimization of Orthopedic Knee Implants

Session C
Information and Data Management
Optical Storage Device
Rewriteable Optical Disk Recorder
Monitoring and Analysis of Data from Complex Systems
Future High Data Rate Systems
Advanced X-Ray Compression Technique
DAVID: The Distributed Access View Integrated Database
Three-Dimensional Perspective Visualization

Session D
Materials Science (Part 1)
High-Performance Polymer Development
Industrial Applications of Graphite Fluoride Fibers
Innovative Applications of Fluoropolymers
Dual Beam Process Diamond-Like Films for Industrial Applications
Plasma-Polymerized Coating for Polycarbonate
The PM200 Lubrication System

Session E
Manufacturing and Fabrication Technology
Robotics in Space-Age Manufacturing
Variable Polarity Plasma Arc Welding
High-Pressure Water Jet Cutting and Stripping
Cost-Efficient Manufacturing of Composite Structures
Rapid Induction Bonding
Reliability and Risk Assessment of Structures
A Semi-Automated Process for Production of Custom-Made Shoes
Lightweight, Fire-Retardant Aircraft Seat Cushioning

Session F
Power, Energy, and Control Systems
Power-By-Wire and Fly-By-Light Technology
The Free-Piston Stiring Engine—From Space to Terrestrial Applications
Solar-Powered Stirling Cycle Electricity Generator
Four Quadrant Control of Induction Motors
Bi-Polar Battery Technology
New CCD Technologies at JPL
Advanced Thermal Technology for Commercial Applications

Session G
Robotics
A Simulator for Robotic Systems
Control System Software, Simulation, and Robotic Applications
Telerobotic Electronic Materials Processing Experiment
Advanced Mechanisms for Robotics
The Flight Telerobotic Servicer and Technology Transfer
The Flexible Agricultural Robotics Manipulator System
Applications of Advanced Man-Telerobot Interfaces

Session H
Sensors and Measurement Technology (Part 1)
Urodynamic Pressure Sensor
Electron Tunnel Sensor Technology
Application of Resistance-Type Strain Gages on High-Temperature Composites
Shuttle Engine Plume Measurements
Al Mass Spectrometers of Shuttle Health Monitoring
Instrumentation for Optical Ocean Remote Sensing

Wednesday, November 28

Concurrent Technical Sessions
8:30 a.m. - 11:00 a.m.

Session A
Artificial Intelligence
Computer-Aided Training and Tutoring
CLIPS: A Tool for Developing Expert Systems
Distributed, Cooperating Knowledge-Based Systems
Electronic Neural Network Technology
Intelligent Vision System for Autonomous Vehicle Operations

Session B
Computer Technology and Software Engineering (Part 2)
Software Reengineering
TAE Plus: A User Interface Development and Management System
Applications of Fuzzy Logic to Control and Decision Making
Genetic Algorithms
Vertical Bloch Line Memory

Session C
Environmental Technology
Physical/Chemical Closed-Loop Water Recycling
Water Quality Analyzer
Bioregenerative Air/Water Purification Systems
The Environmental and Facilities Management System
The Land Analysis System
Commercial Use of EOS Remote Sensing Products

Session D
Human Factors Engineering and Life Sciences (Part 2)
Simulation of Blood Flow Through an Artificial Heart
Three-Dimensional Structure of Human Serum Albumin
Noninvasive Measurement of Minerals and Electrolytes in Tissue
Oxygen Production Using Solid-State Zirconia Electrolyte Technology
Monitoring and Control Technologies for Bioregenerative Systems

Session E
Materials Science (Part 2)
Silicon Carbide, An Emerging High-Temperature Semiconductor
Flexible Fluoropolymer-Filled Protective Coatings
A Conformal Oxidation-Resistant, Plasma-Polymerized Coating
Flame-Retardant Composite Materials
Superplastic Forming of Al-Li Alloys for Lightweight, Low-Cost Structures
Localized Corrosion of High-Performance Metal Alloys in an Acid/Salt Environment

Session F
Optics and Communications
Digital Codec for Real-Time Processing of Broadcast-Quality Video Signals
Advances in Coding Theory for Near-Error-Free Communications
Microwave Integrated Circuits for Space Applications
Optical Communications for Space Missions
Optical Shutter Switching Matrix
Fiber Optic Tactical Local Area Network
High-Precision Applications of the Global Positioning System

Session G
Sensors and Measurement Technology (Part 2)
Quantitative Nondestructive Evaluation
Robotic Control and Inspection Verification
Transfer of a Technology to Measure Skin Burn Depth
Frequency Domain Laser Velocimeter Signal Processor
Field-Deployable Digital Acoustic Measurement System
Laser Optical Disk Position Encoder With Active Heads

Session H
Superconductivity
Applications of High-Temperature Superconductors
Superconducting Microwave Electronics
Superconductive Wires and Devices for Cryogenic Applications
Melt-Processed Bulk Superconductor Fabrication
Large Gap Magnetic Suspension System Ground-Based Experiment

Plenary Session II
2:30 p.m. - 5:30 p.m.

How To Tap Into NASA's Technology Storehouse
NASA experts will explain how to:

- get NASA's help in solving technical problems;
- obtain NASA patents and licenses;
- acquire NASA-developed software;
- participate in NASA-industry applications engineering projects;
- apply for Small Business Innovation Research awards;
- enter into joint R&D projects with NASA.

WHO SHOULD ATTEND TECHNOLOGY 2000

If you are a research director, project leader, design engineer, scientist, technology transfer agent, or small business owner/president, you cannot afford to miss TECHNOLOGY 2000. Top technology managers and researchers have already registered from the aerospace, electronics, computer, industrial equipment, defense, communications, biomedical, materials, power, transportation, and chemical industries. Reserve your place today!

Show Hours

Symposia are scheduled for the 8:30 to 11:00 a.m. and 2:30 to 5:30 p.m. time slots on both Tuesday and Wednesday, November 27 and 28.
Exhibits will be open from 11:00 a.m. to 5:00 p.m. both days.

The Location

All sessions will be held at the Washington Hilton Hotel and Towers, 1919 Connecticut Ave., NW, Washington, DC 20036. A final program will be distributed at registration indicating session room assignments and location. Registrants may then choose which sessions they wish to attend.

Registration Fees

Preregistration: Full registration fee is $150 and includes technical sessions and exhibits for both days. One-day registration is $100. Preregistrants may visit the exhibit hall only at a cost of $20/day. Your badge will be waiting for you in the registration area at the show; a registration confirmation form will be sent to you via mail.

On-site Registration: Full registration will be $200; one-day registration will be $125; exhibit hall only will be $25/day. Registration will be open from 7:30 a.m. to 3:00 p.m. both days.

Hotel Accommodations

The following special rates have been negotiated with the Washington Hilton Hotel for **TECHNOLOGY 2000** attendees: single room - $125; double room - $145. Reservations will be accepted on a first-come, first-served basis and must be made directly with the Washington Hilton Reservations Dept., (202) 483-3000.

Transportation

Ground: The Washington Hilton Hotel is conveniently located near the DuPont Circle stop on the Metro Red Line, and offers plenty of indoor parking.
Air: Special arrangements have been made with United Airlines through Travel Services Group for discounted air fares to attend **TECHNOLOGY 2000**. You can save up to 40% on coach fares or receive an additional 5% off already discounted fares (with restrictions). Make your reservations as soon as possible to assure the flight schedule of your choice. Call 1-(800)-336-0227 between 9:00 a.m. and 5:30 p.m. Eastern time, Monday through Friday.

The Sponsors

TECHNOLOGY 2000 is sponsored by NASA, *NASA Tech Briefs* magazine, and the Technology Utilization Foundation, a not-for-profit organization dedicated to technology transfer. For further information contact Joseph Pramberger, show manager, at (212) 490-3999.

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Sealing Nitrogen Tetroxide Leaks

Leaks can be stopped in place, without draining or replacement of leaking parts.

Lyndon B. Johnson Space Center, Houston, Texas

The use of Furmanite FSC-N-6B (or equivalent) sealant in a clam-shell sealing device makes it possible to stop leaks of nitrogen tetroxide through defective or improperly-seated plumbing fittings. This type of repair was devised to stop leaks of nitrogen tetroxide oxidizer in a vent line of a small rocket motor on the Space Shuttle. The leak-stopping technique can also be used on plumbing containing hydrazine and other hazardous fluids, and the repair can withstand severe temperature, vibration, and shock.

The leaking fitting [a Dynatube (or equivalent) line fitting or a weld sleeve, for example] or the region of a tube containing a leak is covered with a clam-shell device equipped with a filling port (see Figure 1). This device is filled under pressure with the sealant material until the material is extruded through the thin spaces between the mating surfaces (see Figure 2).

This work was done by George G. Garrard, Donald W. Houston, and Frank D. Scott of Rockwell International Corp. for **Johnson Space Center**. *No further documentation is available.*
MSC-21600

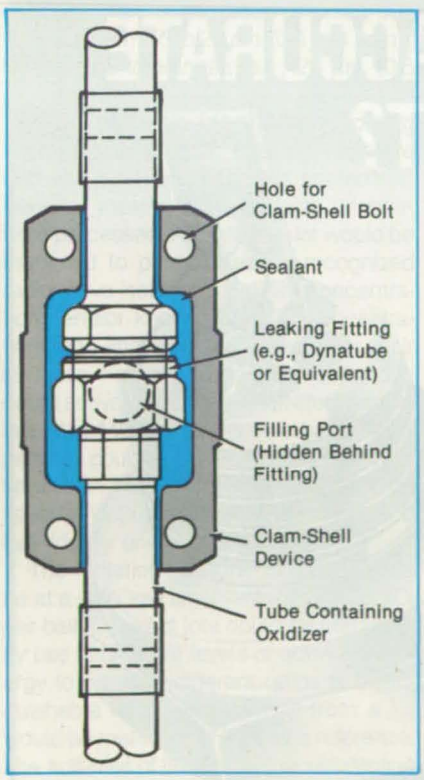


Figure 1. The **Clam-Shell Device** covers the leaking fitting. It is not necessary to remove the leaking fitting or otherwise disturb the plumbing.

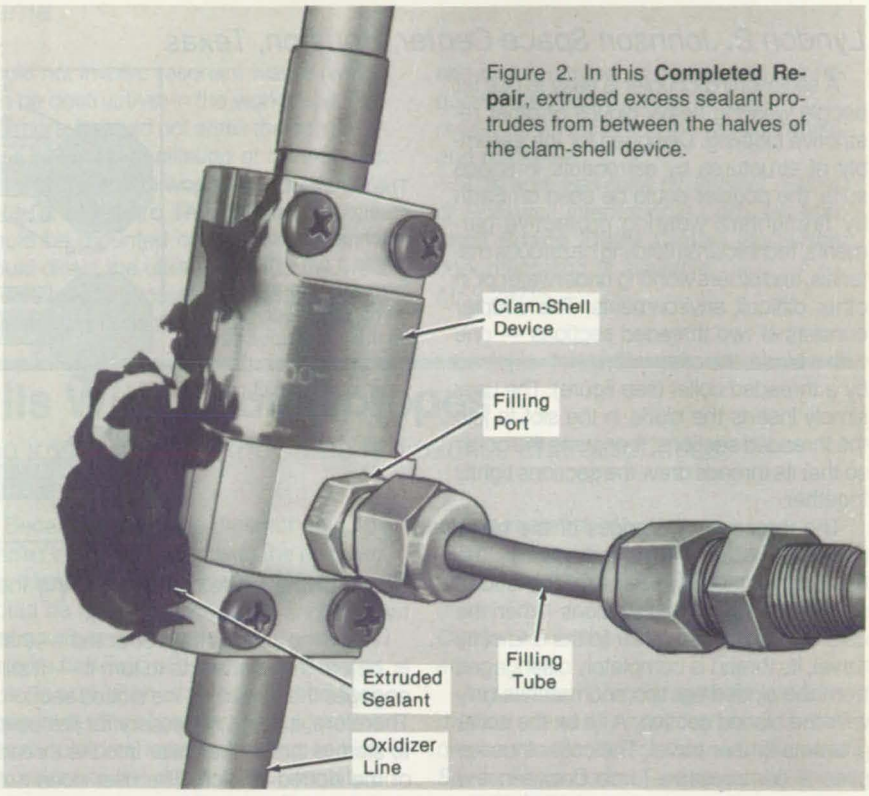


Figure 2. In this **Completed Repair**, extruded excess sealant protrudes from between the halves of the clam-shell device.

Characterization of Robot Work Cell

A mathematical model of tooling and workspace is improved iteratively.

Marshall Space Flight Center, Alabama

An iterative process of measurement and computation is used to characterize the work cell of a robot, increasing the accuracy of a mathematical model of the work cell. Such characterization is needed because the model is to be used in off-line programming (OLP) to compute paths to control the motion of the robot. The characterization process increases the accuracies of the model and paths; for example, by correcting for differences between the placement, orientation, and dimensions of the actual workpiece, tooling, and robot and those specified in the initial or previous iteration of the model.

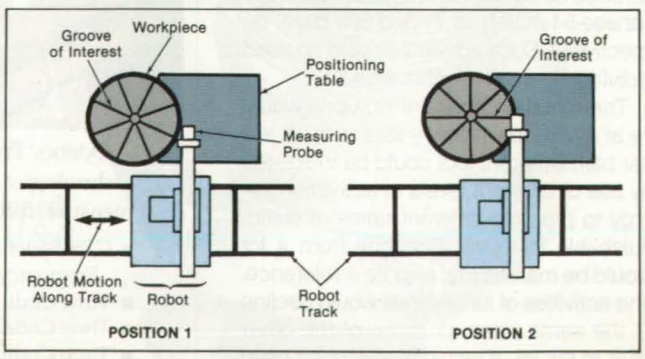
Heretofore, characterization has involved the use of highly specialized, precise, expensive measuring devices capable of defining locations in three-dimensional space and has yielded accuracies of the order of 0.01 in. (0.25 mm). In the tungsten/inert-gas welding process for which the present method of characterization was conceived, accuracy of ±0.5 in. (12.7 mm) suffices, and budgetary constraints dictate the use of less expensive (and, therefore, less-accurate) measuring equipment.

To characterize with the required accuracy without expensive measuring equipment, the present method establishes two guidelines: (1) robot-joint configurations are defined relative to other such configurations rather than expressed in terms of positions measured in an arbitrary coordinate frame, and (2) the geometric-zero configuration and position in the mathematical model can differ from the geometric-zero configuration and position defined (usually by the manufacturer's specification) in the robot controller as the zero configuration and position and as the basis for all internal calculations of positions. Under the second guideline, the geometric-zero joint configuration of the mathematical model can be chosen to be one that can be verified by simple measurements. It is important to be able to make such a choice because the geometric zero defined in the controller can be one that is not easily verifiable (see figure).

With OLP, positions and configurations are computed externally to the robot controller. Robot trajectories thus computed are transferred to the robot controller in the form of files of joint-position-encoder values that do not depend on the geometric zero. To increase the accuracy of the initial or previous iteration of the model, test trajectories are created off-line and executed in the work cell. In creating a test trajectory, test points are such verifiable locations as the ends of tooling grooves on a positioning table. Robot motion is then simulated, commands are generated, and the programs downloaded to the robot controller. With the measurement probe in place, the test trajectory is executed. Each test point is measured with respect to the verifiable location to determine the accuracy of the program and model. By measuring several positions within the work cell, one can establish trends that link inaccuracies to specific joint offsets. After each change, the test trajectory must be resimulated, commands regenerated, and the new files redownloaded to the robot controller to account for the changes in the model. This iterative process is complete when the desired accuracy is obtained.

This work was done by Ronald R. Anderson, Vincent Y. Paternoster, and Wayne A. Guthmiller of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 3 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-29731.



When the Workplace Lies at the Geometric Zero defined by manufacturer's specification in the robot controller (position 1), the angular position of the workpiece is such that the groove of interest lies at an angle with the robot track. This angle is difficult to verify with the measuring probe. When the workpiece lies at the geometric zero defined by the user (position 2), the groove of interest lies parallel to the robot track. This is easily verified in that the probe reading should remain constant as the robot moves along the track.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Polyhedral Observation Cupola

A strong, lightweight structure would include facets with windows.

A report describes a concept for an observation cupola for Space Station *Freedom*. The cupola would be used by crewmembers to observe docking of the Space Shuttle, servicing of payloads, extravehicular activity, and other operations in which they could help by observing. The report includes computer-generated pictures that realistically depict crewmembers' positions, workstation positions, and views through various windows.

The cupola would include 15 triangular metal panels, welded together in the form of part of an icosahedron similar to a geodetic dome. (The 5 panels that would complete a perfect 20-sided icosahedron would be replaced by a cylindrical base that would serve as a platform for the crewmembers.) The diameter of the dome would be about 6 ft (2 m). Like a terrestrial geodetic dome, it would be a relatively lightweight structure that could withstand large stresses.

Each triangular panel could contain a circular window with a double glass pane; if one of the panes should fail, it could be removed and replaced without disturbing the other. The circularity of the window would allow the use of panes that have been prestressed by encircling them with compressing bands. Compressive prestressing would give the panes approximately the strength of tempered glass; therefore, they could be made relatively thin and light in weight.

The size and shape of the windows would be the same as those of the windows in the habitation and laboratory modules of the Space Station. Therefore, all panes from different windows would be interchangeable, and the number of spare panes that would have to be stored could be reduced.

This work was done by Karen S. Edelstein and Gerald D. Valle of **Johnson Space Center**. *To obtain a copy of the report, "Icosa Cupola for the Space Station Freedom," Circle 57 on the TSP Request Card.*
MSC-21689

Mathematics and Information Sciences

Trigonometric Polynomials for Estimation of Spectra

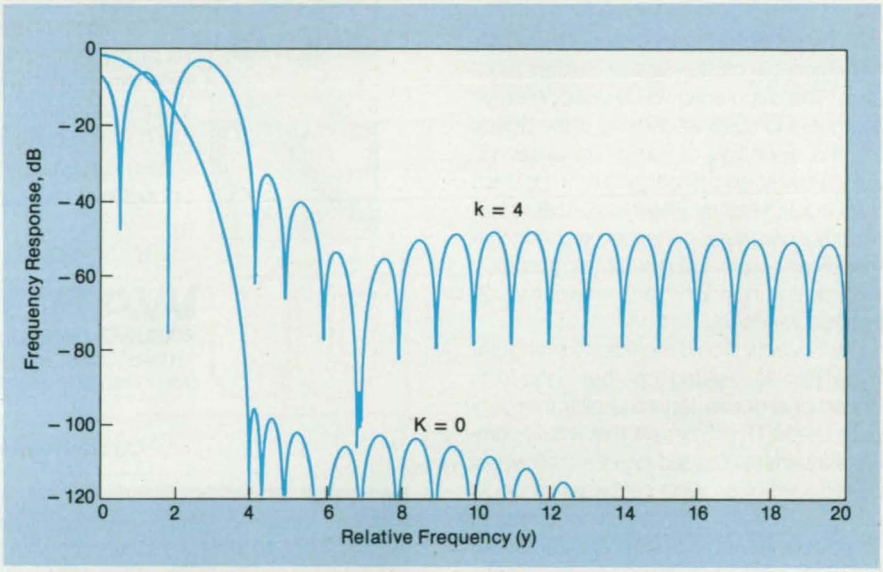
Suboptimal substitutes for discrete prolate-spheroidal data windows are easier to compute.

NASA's Jet Propulsion Laboratory, Pasadena, California

Orthogonal sets of trigonometric polynomials can be used as suboptimal substitutes for the discrete prolate-spheroidal "windows" of the Thomson method of estimation of spectra. As used here, "windows" denotes weighting functions used in sampling time series to obtain their power spectra within specified frequency bands. The simplified windows are designed to require less computation than do the discrete prolate-spheroidal windows, albeit at the price of some loss of accuracy.

With respect to a frequency band $[f_0 - W, f_0 + W]$, the leakage $L(g, W)$ of a function g of discrete or continuous time is defined as the fraction of its total energy contained in frequencies outside $[-W, W]$. As such, the leakage of a window is a measure of its inaccuracy. The discrete prolate-spheroidal windows of the Thomson method are orthonormal and optimal with respect to leakage — that is, they have minimal leakage in a space of sequences that contain the number of terms, N, of the time series.

A recent effort to simplify the calculation of orthogonal windows and to extend their applicability to unevenly-spaced and multidimensional data involved the use of trigonometric polynomials. In this approach, the coefficients of the polynomials and their leakages are respectively the eigenvectors and eigenvalues of a certain matrix, the entries of which depend on N. In the new approach, one obtains a further simplification for evenly-spaced one-dimensional data by deriving the coefficients and leakages of an orthonormal set of continuous-time trigonometric polynomials that do not depend on N. They are converted to discrete-time data windows by sampling them at N properly-chosen points. The new, simplified windows are called "sampled trig prolates" (see figure).



These **Frequency Responses** are those of the $k = 0$ and $k = 4$ trig prolate windows of degree 4 for bandwidth $w = NW = 4$. (The complete sequence includes windows $k = 0$ to $k = 8$.) The relative frequency, y, is the deviation from the middle of the frequency band, in units of the reciprocal of the sampling period. The total energy of each window is 1.

For $w = NW = 2$ to 5, and $8W$ not greater than the Nyquist frequency (i.e., $N \geq 16w$), one pays a leakage penalty of at most 2.6 dB for not using the optimal discrete prolate-spheroidal windows. In return, one needs merely to evaluate certain trigonometric polynomials of degree w. In contrast, the evaluation of the discrete prolate-spheroidal windows requires the solution of an $N \times N$ symmetric Toeplitz matrix eigensystem. The prospective user of the Thomson method might regard the 2.6-dB penalty as an acceptable price to pay for avoiding such complexity.

This work was done by Charles A. Greenhall of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 48 on the TSP Request Card.*
NPO-17885

Cooperating Expert Systems for Automated Monitoring and Diagnostics

Human operators will be freer to perform nonrepetitive tasks.

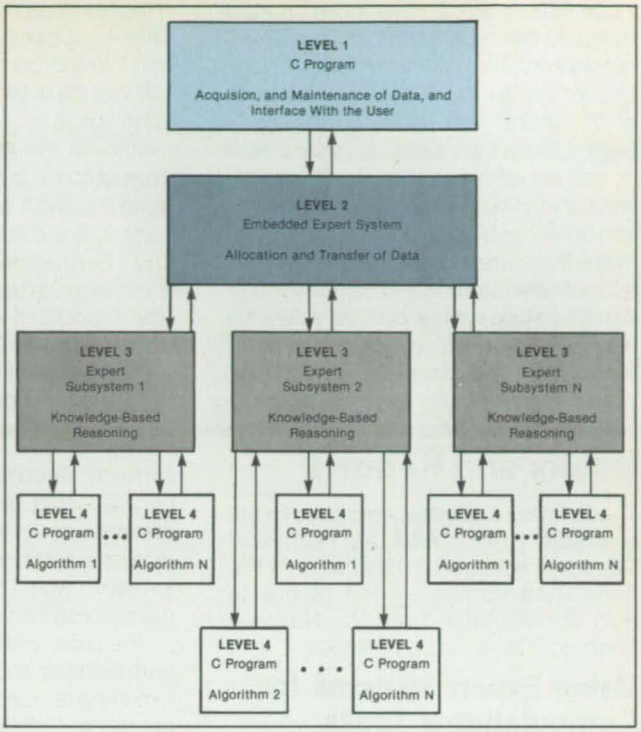
NASA's Jet Propulsion Laboratory, Pasadena, California

An expert software system for monitoring multiple streams of sensory data from interacting equipment subsystems is undergoing development. The original version of this software is intended to assist human analysts in the interpretation of telemetry data that indicate the operating statuses of the subsystems of a spacecraft, enable the analysts to maintain the desired mode(s) of operation, and help the analysts to correct anomalies in the subsystems or in the overall spacecraft system. Other versions could be devised for industrial monitoring and analysis tasks that are similarly complicated.

Computer automation of the monitoring task offers several advantages. First, it relieves the human operators of the repetitive and boring task of routine monitoring, wait-

ing for malfunctions that occur infrequently and unpredictably. By so doing, it frees the analysts for more challenging, nonroutine tasks. Another advantage is the preservation of routine and reportable components of expertise in the face of changes in personnel. Yet another advantage is provision for the integrated analysis of data from multiple spacecraft (or equipment) subsystems in cases in which a malfunction in one equipment subsystem can manifest itself in changes in the sensory data from other equipment subsystems.

The expert software system is organized hierarchically to monitor multiple spacecraft (or equipment) subsystems (see figure). In this software hierarchy, each software module has its own separate knowledge base, each with its own inferencing process. All the knowledge bases are incorporated into the same software hierarchy. A top-level (level-1) program performs functions relevant to access to data, maintenance of data, and interface with the user(s). This level also passes data to the level-2 expert system, which allocates the incoming data to the appropriate third-level expert system for analysis. Each third-level expert system contains production rules for a single (spacecraft or equipment) subsystem. These perform analyses to identify anomalous situations and provide recommendations for corrective action. They also report their findings upward to the second-level expert system, which may pass the findings downward to another third-level expert subsystem for appropriate action, depending upon relevance. At the fourth and lowest level of the hierarchy are small programs that perform algorithmic analyses as requested by the expert subsystems.



The **Expert Software System** is organized hierarchically to monitor multiple equipment subsystems simultaneously. Each expert software subsystem is responsible for one of the equipment subsystems.

For maximum speed and portability, the top- and bottom-level programs are written in C. The expert system and subsystems located in the second and third levels, respectively, are programmed in an expert-system software shell that makes it possible to embed the expert system into higher-level C code and enables the expert subsystems to call lower-level external functions.

A prototype expert software system for monitoring three spacecraft subsystems has been tested successfully on the Sun 4 workstation. However, to add the second expert system for coordinating the analysis of multiple spacecraft subsystems in nearly real time, it may be necessary to transfer the software to other computing equipment that supports higher speed and multiprocessing.

This work was done by Ursula M. Schwuttke and John R. Veregge of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 161 on the TSP Request Card.*
NPO-17804

Forward Stochastic Nonlinear Adaptive Control Method

The main advantage is simplicity of programming and reduced complexity with clear performance/computation trade-offs.

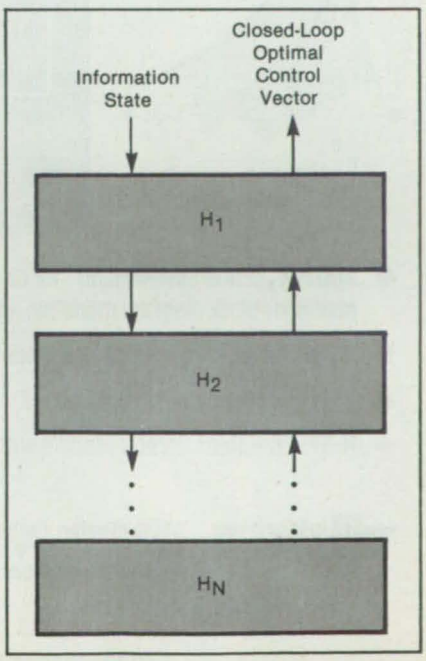
NASA's Jet Propulsion Laboratory, Pasadena, California

A promising new method of computation for optimal stochastic nonlinear and adaptive control is undergoing development. Essentially, the new approach is to solve systematically the stochastic dynamic programming equations forward in time, using a nested-stochastic-approximation technique.

The system in question is represented by discrete-time nonlinear state and measurement equations. The system state, which is assumed to be only partially observed, is specified by a probability density at the initial time. The process and measurement equations include noise, the discrete-time components of which are represented by sequences of zero-mean white-noise vectors that have mutually independent components. These noise vectors are statistically independent of the random initial state, and have process statistics specified by known probability densities.

The optimal-control problem is to minimize a specified cost function over the class of admissible control policies. An admissible control policy is defined by a sequence of control vectors, each of which maps the information state (the measurement information causally available at a given instant) into the input vector at that instant.

Using a forward method, the optimal control vectors are computed along a specific realization of the optimal trajectory through state space. At each instant, only



The **Computational Architecture** for the new method involves a sequence of subalgorithms called "H blocks," which can be cascaded.

those future optimal trajectories causally related to the present information state are considered. The computational architecture for this approach involves a cascade of "H blocks" (see figure). At the top of each H block, the information state is read in, and the corresponding closed-loop optimal control vector is read out. At the bottom of each H block, the future information states that correspond to the simulated trajectories are read out, and the corresponding closed-loop optimal control vectors are read in. This forward approach is quite different from the classical approach, in which the stochastic dynamic programming equations are solved backwards in time — a procedure that embeds the problem into a larger one and requires computation of the optimal solution over the entire state space.

Although this approach involves much computation, it is simple to program on a computer, and it provides a straighforward numerical solution for problems of this kind. Furthermore, it provides an alternative to the usual "curse of dimensionality" associated with solving the dynamic programming equations backward in time; the "curse" takes a new form in which the amount of computation depends on the amount of uncertainty in the problem and the length of the horizon. As a matter of significant practical interest, it is shown that the cost of computation decreases monotonically as the complexity of the algorithm is reduced. This feature provides a strategy for suboptimal control with clear tradeoffs between performance and the amount of computation.

This work was done by David S. Bayard of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 53 on the TSP Request Card.*
NPO-17861

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Using Expert Systems for Computational Tasks

A transformation technique may enable inefficient expert systems to run in real time.

A paper suggests the use of a knowledge compiler to transform the knowledge base and inference mechanism of an expert-system computer program into a conventional computer program. The main benefit would be faster execution and, therefore, reduced processing demands. In avionic systems, for example, the transformation would reduce the need for special-purpose computers.

The paper presents an overview of expert systems and a brief comparison of expert-system programs with conventional programs. It discusses applications of expert systems to avionics and explains the concept of the knowledge compiler by using examples of forward- and backward-chaining systems.

Expert systems offer an aircraft pilot both knowledge and assistance. They help the pilot cope with the complexities of, and interactions among, subsystems in new aircraft. Indeed, expert systems may provide the only way of dealing with some advanced aircraft. However, expert systems impose a heavy computational burden — a burden that must be executed in real time in an aircraft. Expert systems operate by iterative processes that are necessarily inefficient, and the inefficiency increases with the size of the knowledge base.

The transformation of the rules of an expert system into conventional computer code yields a logically equivalent representation of the knowledge base and inference mechanism. Of course, the flexibility of the expert system has been changed into the rigidity of a conventional code — but if the transformation is done automatically, nothing is lost. Furthermore, the program thus generated can be executed much faster and by any number of processors.

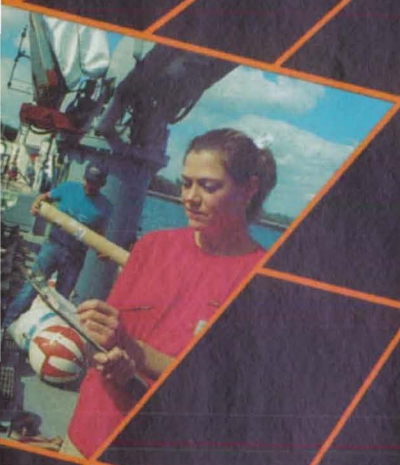
The transformation would be done by a knowledge compiler in a process reminiscent of that of a standard compiler. When the knowledge base in the expert system is modified, the compiler would generate a new conventional source code; the old code would be discarded.

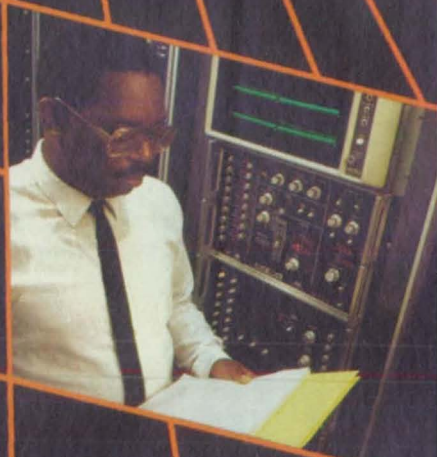
The transformation concept is not limited to applications in avionics. In research and development laboratories, for instance, symbolic processors offer many benefits but tend to be costly single-user, special-purpose systems. The transformation technique would convert such expert systems from symbolic processors to numeric processors that can be used on widely available general-purpose computers.

This work was done by Eugene L. Duke, Victoria A. Regenie, and Marylouise Brazee of **Ames Research Center** *and Randal W. Brumbaugh of PRC Kentron. Further information may be found in NASA TM-88263 [N86-24687], "An Engineering Approach to the Use of Expert Systems Technology in Avionics Applications."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12137

NUSC Engineers Go Places.





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Circle Reader Action No. 324

Principles and Applications of Dual Adaptive Control

Simulations indicate the superiority of a dual controller over a "cautious" controller.

A report discusses principles of design of actively adaptive dual controllers. The focus is upon the derivation of control laws for a dual controller that can enhance the identification of the parameters of a mathematical model of a multiple-input/multiple-output system, while controlling it at the same time. In general, the tasks of identification and control impose competing requirements.

The design of a controller is the result of an algorithm that optimizes its performance as measured by a performance index or cost function. This index is generally defined as a function of actual and desired outputs of the system to be controlled. Usually, the complexity of the system makes it necessary to settle for a suboptimal solution to the design problem, based on probability density functions for the parameters. In such a stochastic system, the control has a dual effect: it affects both the present state as well as the future state of the system and/or the uncertainty in the parameters.

A dual controller, the design of which explicitly utilizes this dual effect, offers significant potential for the improvement of the control of an uncertain linear plant. Such a controller probes the system to enhance immediate identification of the parameters in order to increase the accuracy of the subsequent control decisions and regulate the system at the same time. Thus, the dual controller has two different tasks and compromises between good control and good identification of the parameters.

Two controllers that do not account for any dual effect are also investigated. One of them, called the heuristic certainty equivalence (HCE) controller, estimates the parameters on the basis of all available information and uses those estimates as though they were true.

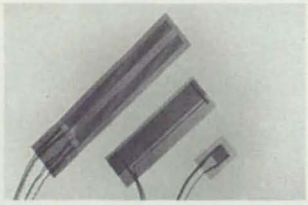
The other one, called the "cautious" controller, uses the estimated parameters as well as their associated current covariances. In an uncertain situation, this controller can be overly "cautious" because of the uncertainty in the parameters. Another disadvantage of this controller is the turnoff phenomenon in which the control almost vanishes during significant lengths of time. Thus, the controller cannot estimate the parameters and loses control over the system.

The adaptive-dual-control solution developed in this study utilizes the dual effect by performing a Taylor-series expansion of the expected future value of the cost function. This solution modifies the law of the "cautious" controller with a numerator "probing" term and a denominator correction term. Monte Carlo simulations indicate that this solution prevents the turnoff phenomenon prevalent with a cautious controller. However, on a few occasions this solution demonstrates excessive probing; this is handled by a control limiter. Analysis of the simulations shows the superiority of the dual controller over the "cautious" and HCE controllers. The principal improvement is in the avoidance of situations like the slow convergences and turnoffs typical of the "cautious" controller.

This work was done by Purusottam Mookerjee of the University of Connecticut for **Ames Research Center**. *Further information may be found in NASA CR-177485 [N88-28038], "Dual Adaptive Control: Design Principles and Applications."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12310

New on the Market



Eaton Corporation's Pressure Sensors Division, Bethel, CT, has introduced a new line of **flexible RTD temperature sensors** suitable for application to both flat and rounded surfaces. The units meet resistance versus temperature characteristics of ASTM, DIN, IEC, and American Reference standards for platinum. Nickel, nickel-iron and copper curves are also available. Standard resistance at 0°C is 100 ohms, ±0.12 percent.

Circle Reader Action Number 800.

Castall, Weymouth, MA, has introduced the E-414FR **thermally-conductive epoxy** for use on glass diodes, electronic ballasts, power supplies, PCBs, and other circuits. A 1:1 mix ratio makes the epoxy easy to pour and its 10,000 cps viscosity rating allows it to saturate dense configurations. Listed by UL's 94V-O specifications for flame retardancy, E414-FR provides semi-flexible (75D shore) protection for parts in assembly, during temperature cycling, and throughout the shipping process.

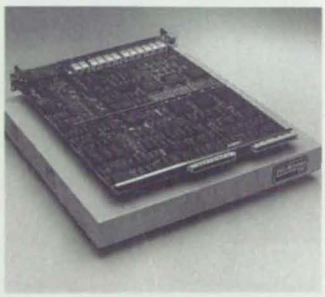
Circle Reader Action Number 794.

3-D Visions, Redondo Beach, CA, has announced the availability of GRAFTOOL 3.0, the first **2D and 3D graphics package** to provide on-screen visual data analysis on a standard PC, with mainframe level power. GRAFTOOL offers 26 technical graph types, from scatter plots to polar plots, contours to surfaces. Onscreen data can be viewed from any angle; changed; extracted, smoothed to best fits, and contoured -- without leaving the graph. Compatible with Lotus 1-2-3, Quattro, and ASCII files, GRAFTOOL can display up to 268,000,000 data points, complete with Greek and math symbols, error bars, and unrestricted text placement.

Circle Reader Action Number 792.

VideoWindows HR from New Media Graphics, Billerica, MA, brings **full-motion video in a window** to high-resolution workstation screens such as Sun, DEC, Silicon Graphics, and Tektronix. Operating as a peripheral to the host workstation, VideoWindows HR digitizes incoming video from standard NTSC or PAL cameras, VCRs, videodiscs, cable TV, or still-frame video sources in real-time and scan-converts it to match the monitor's display requirements. The images approach the quality of high-definition television, according to the manufacturer, and can be displayed full-screen or in any size window. Applications include visualization, training, desktop publishing, and military C3I.

Circle Reader Action Number 796.



X-Lib **software** from EMT Inc., Bellingham, WA, automatically creates icons from any part of an AutoCAD drawing, producing graphical pop-up icon menus of symbols and blocks. To retrieve a symbol, the user looks it up in the icon menu. X-Lib will insert it to a desired scale as an AutoCAD block with attached attributes. This feature eliminates the need to remember block names and directories because symbols are stored as graphical images.

Circle Reader Action Number 798.

Electronic Associates Inc., West Long Branch, NJ, has introduced the VISIDAQ® menu-driven **video strip chart recorder** for real-time data collection and display. Up to 178,000 samples/sec capability allows capture of 9 kHz waveforms. Four stages of user-definable limit checking and automated triggering options are included.

Circle Reader Action Number 790.

New on the Market

The **PPC2 pressure controller/calibrator** from DH Instruments, Tempe, AZ, is designed for use by local operators as a stand-alone, automated workstation. It integrates full-function control and measurement in one portable, compact housing. The front panel keypad and display allows a library of custom calibration routines to be set up and stored for recall and execution. Built-in quartz-crystal-based reference pressure sensors give the PPC2 accuracy to +/- 0.01% F.S. +0.01% of RDG.

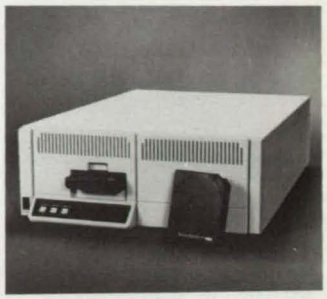
Circle Reader Action Number 782.

A toolbox of C functions for writing third-party CAD/CAM applications is available from Building Block Software,Somerville,MA.The **CAD/CAM Developer's Kit**™ provides users with full 3D DXF, 2D and 3D display and geometry operations, and list management capabilities. It is suited for developing DXF file viewer add-ons to database programs, numerical control code generators, finite element mesh generators, 3D piping layout tools, and printed circuit board layout checking programs, and can be used to build the internal "geometry engine" of a CAD/CAM system.

Circle Reader Action Number 778.

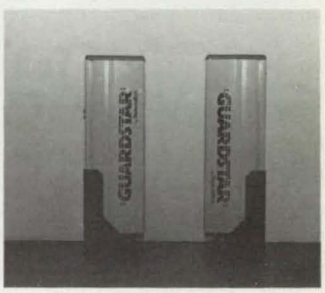
The Turbo-Jet from FTS Systems, Stone Ridge, NY, provides economical **temperature testing of electronic components and circuit boards.** The compact unit delivers 5 to 15 scfm air flow at controlled temperatures from -75 to +230 C for rapid temperature cycling and thermal shock applications. A dual axis holding arm moves the test shroud away from the ATE test fixture for easy access to the test area.

Circle Reader Action Number 784.



The first PC-based IBM compatible 3480 **tape subsystem** for PC's has been introduced by Shaffstall Corporation, Indianapolis, IN. The PC-3480 allows PC users to upload and download data to an IBM mainframe via 200 MB 3480 cartridges, at up to 1 megabyte per second. System software provides for menu-driven interfacing and the addressing of up to seven additional SCSI devices.

Circle Reader Action Number 786.



GUARDSTAR from the Tapeswitch Corporation, Farmingdale, NY, is a self-contained photo-electric **machine guard** featuring a modular design. Its modular transmitters and receivers are continually checked by three microcomputers. Single component failures or other faults cause the guarded machine to revert to a safe condition, maximizing operator safety. The infrared system discriminates spurious light sources, responding only to its own twin unit.

Circle Reader Action Number 788.

Acme Electric's Advanced Energy Systems Div., Tempe, AZ, will produce a new line of maintenance-free, sealed **nickel-cadmium batteries**. The battery's plates are constructed of a nickel-coated fiber matrix into which the active material - nickel hydroxide in the positive plate and cadmium hydroxide in the negative - is embedded. Since the fibrous plates are 90 percent porous, they provide excellent utilization of the battery's active material, resulting in improved low-temperature performance, low charge coefficient, and higher power capabilities than sintered batteries.

Circle Reader Action Number 780.

Greetings from Alabama:

The State of Alabama is honored to be featured in this issue of *NASA Tech Briefs*. We believe it is a very appropriate way to introduce Alabama's technical expertise to the nation's high-tech "movers and shakers."

High-tech firms are an integral part of the growth of the economy in Alabama, named one of the top five states in economic development for 1989. Alabama has a storehouse of surprises for companies and individuals in the high-tech field. A world-class medical center, research facilities the equal of those anywhere in the United States, and universities conducting scientific work important to our national defense are only some of the scientific and technical activities taking place here.

Very few people are surprised at Alabama's climate; the state's Sunbelt location ensures an almost ideal year-round climate. But many people are surprised that Alabama's business climate is helping industry grow and prosper.

Industrial development in Alabama has topped $2 billion for a record third straight year. A recent publication by the U.S. Small Business Administration announced Alabama ranks third in the nation in new business incorporations.

I invite you to visit Alabama. We're a state on the move. Even though we have an enormous amount of high-tech expertise to offer, the best is yet to come. Come and be surprised. Alabama is definitely open for business.

Guy Hunt

Guy Hunt, Governor

ADVANCING TECHNOLOGY IN ALABAMA

Computer-generated ribbon drawing of the enzyme Human Gamma Interferon, produced by the University of Alabama at Birmingham's Center for Macromolecular Crystallography.

"Birmingham has become internationally recognized in diverse fields of biomedical and health-related research," said Martin Tilson, Jr., director of the Office for the Advancement of Developing Industries (OADI) at the University of Alabama at Birmingham (UAB). OADI was founded in 1986 to help commercialize the innovative research emerging from Alabama's scientific community. It features a 36,000-square-foot incubator facility that provides low-cost office and laboratory space to 13 tenant firms and associate companies. Two companies have already graduated from OADI to stand on their own as successful businesses.

Among OADI's current tenant firms, three are standout examples of the potential for translating university-based research into commercially useful technology: BioCryst, Inc.; CMS Research, Inc.; and Bioelastics Research, Ltd.

BioCryst is engaged in structure-based drug design, the development of new drugs based on the detailed knowledge of protein structures. The company is in large part an outgrowth of research at UAB's Center for Macromolecular Crystallography, directed by Dr.

Materials researchers at UAH have developed several facilities for reduced gravity experiments on the NASA KC-135 aircraft.

Charles E. Bugg. Bugg's laboratory has used the space shuttle to grow large crystals of medically significant proteins, such as those implicated in AIDS and diabetes, which are then mapped in precise detail by X-ray crystallographic techniques. BioCryst is taking these methods a step further, using computers to custom-design new drugs that interact with these proteins to produce clinically desirable results. The company is moving toward the market with four drug projects. In the last year, a management team has been assembled with significant experience in the pharmaceutical industry.

CMS Research Corporation has already put its first products on the market and now enjoys sales of more than $1 million annually. The company develops environmental monitoring devices that detect minute (parts per trillion) atmospheric concentrations of toxic gases, especially volatile organic compounds. CMS's initial products have been mainly targeted toward U.S. government markets, but the company is working to expand their applications to hazardous waste sites and manufacturing plants.

Bioelastic Research Ltd. (BRL) seeks to commercialize research by Dr. Dan Urry's Laboratory of Molecular Biophysics at UAB. The research focuses on a new biomaterial composed of synthetic analogs of muscle and other elastic animal fibers. These materials stretch or shrink in response to electrical or chemical stimulation and can be programmed to biodegrade. BRL has developed a material which behaves remarkably like natural fibers, and can be formed into gels, powders, and sheets for medical and industrial applications such as prevention of post-surgical adhesions, replacements for synthetic ligaments and blood vessels, and possibly even saltwater desalinization. The U.S. Navy is funding two research contracts at BRL on adhesion prevention and wound healing applications. Plans are under way to create a development company that will produce the bioelastic material in large quantities.

Consortium For Space Life Sciences

The close proximity of the University of Alabama in Huntsville (UAH) to NASA's Marshall Space Flight Center has shaped the university's research and educational programs since the days of Apollo in the 1960s. It continues to do so as the nation looks ahead to the development of a permanent, manned space station and to exploratory missions which will take mankind farther from the safety of Earth's environment than ever before.

The Consortium for the Space Life Sciences, founded in 1987, is a logical outgrowth of UAH's long history of involvement with America's space program. Its mission is to work toward the development of technology to meet the life sciences needs of the next century and to promote the free exchange of ideas and skills among diverse scientific disciplines.

Most of the consortium's work has been directed toward the needs of NASA's space station Freedom project. Under contract to the Marshall Center, the consortium provides consulting services to NASA's Environmental Control and Life Support System (ECLSS) group. This engineering team is designing and testing physical-chemical methods to reclaim and recycle air and water aboard space station Freedom. The consortium advises the ECLSS group on issues such as microbial and chemical contamination of recycled water. Guidance is also provided to NASA on the establishment of institutional review boards, test subject safeguards, monitoring requirements, and experimental design.

Moreover, the consortium supports the Boeing Company's effort in NASA's ECLSS water recovery test program. Activities include the drafting of a study protocol for the determination of urinary constituents in oxone/sulfuric acid-treated urine, and a plan for assessing the effects of this pre-treatment process on urinary metabolites.

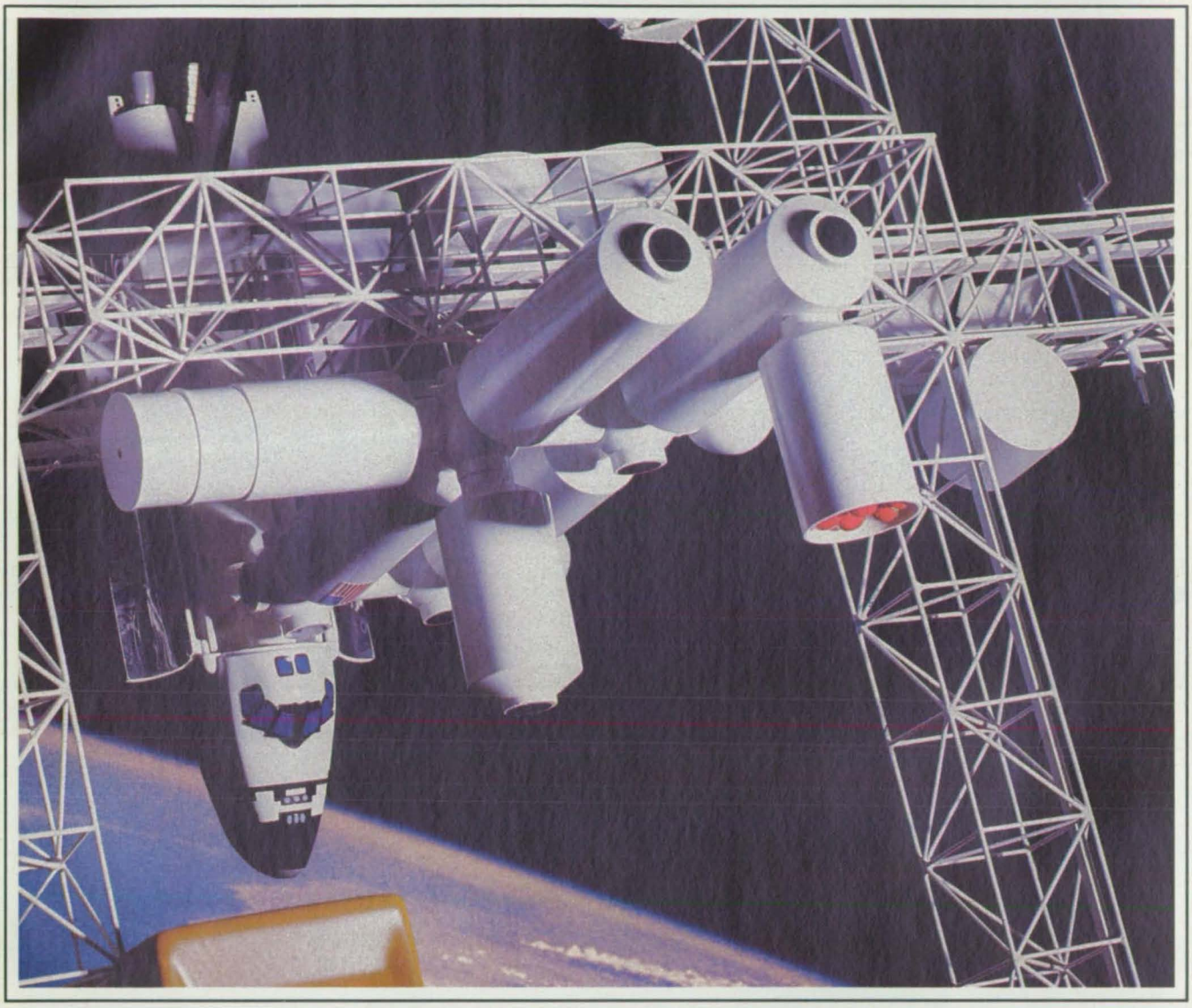
Major laboratory support for consortium activities is provided by the Kenneth E. Johnson Research Center on the UAH campus. The center houses an environmental testing laboratory, providing more than 6000 square feet of dedicated research space, and features two Cray supercomputers, as well as instrumentation for water analysis, including ion, gas, and liquid chromotography; atomic absorption spectrophotometry; and mass spectroscopy.

Space Crops

Alabama's Tuskegee University is conducting research under the auspices of NASA's Life Sciences Division to study growth of the sweet potato in a space environment. The sweet potato is one of eight crops under evaluation that could provide the basis for a balanced and varied diet for a space inhabitant.

Tuskegèe's research is aimed at hydroponically growing the potato. Media other than soil, such as sand and gravel, were initially evaluated, but these posed potential problems, given the mass and

Alabama's technology is felt in some of the most far-out circles.



A great climate for a sophisticated business.

Alabama has the most sophisticated technological talent of any place in the country. We produce designs and facilities as modern as any in the world.

In fact, the space station is being designed in Huntsville, Alabama, where much of the American space program has been conceived and executed.

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We have a world-class medical center, research facilities equal to any in the United States, and universities conducting scientific work important to our national defense.

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Circle Reader Action No. 350

volume limitations on space cargo. The Tuskegee team then successfully experimented with a nutrient film technique (NFT) which involves the passing of a thin film of nutrient-enriched water solution over the sweet potato plant's root system. Tuskegee's redesigned NFT system has earned the university a patent and is producing sweet potatoes on a consistent basis.

The second phase of this research focuses on quantifying parameters such as temperature, humidity, and light intensity for plant growth using artificial lighting systems and enclosed environments. After basic conditions are determined at Tuskegee, follow-up research with large communities of plants will be conducted at the Kennedy Space Center's Biomass Production Chamber. Research related to the NFT system will not only serve the nation's space agriculture needs but will also benefit Earth-based farmers by providing information on how to more efficiently grow potatoes and other related root crops.

New Methods For Producing Semiconductor Materials

Researchers at UAB, the Marshall Center, and Rockwell International are working to improve methods for producing "third-generation" semiconductor materials. Formerly known as II-VI semiconductors, the materials will have important applications in infrared radiation detectors. For some portions of the infrared spectrum, no other type of detector is available. The researchers hope to use the microgravity environment of space to produce large crystals of these materials, which have been difficult to grow on Earth due to the effects of gravity. They are looking at semiconducting alloys made of mercury, cadmium, and tellurium (HgCdTe); mercury, zinc, and tellurium (HgZnTe); and mercury, zinc, and selenium (HgZnSe). The goal is to produce large, homogenous crystals of these alloys which can then be sliced into wafers to be manufactured into semiconductor devices. The ability to produce large quantities of these materials is expected to make large-area arrays of infrared detectors more economically feasible.

An experiment that will attempt to grow crystals in space has been scheduled for a March 1992 space shuttle flight. In preparation for the mission, Dr. Rose Andrews and her students in UAB's Materials Science and Engineering Department are involved in an extensive ground-based study. Using directional solidification, Dr. Andrews will grow crystals of several II-VI alloys that will help determine optimal growth conditions for the space flight. The ground-based studies will also determine the characteristics of Earth-grown crystals, such as the influence of various growth conditions on the densities and distribution of crystalline defects.

Materials Processing Science AT UAH

Research activities in materials at the University of Alabama in Huntsville help to provide a vehicle for transferring technology between NASA, industry, and other universities. Of particular interest are the materials processing programs in reduced gravity and non-destructive evaluation.

In addition to space experiments, UAH also manages several programs which assist the materials scientist or engineer in performing preliminary experiments in less costly experimental facilities and provide an opportunity to explore the potential of a low gravity environment for preparing new or unusual materials.

The Johnson Research Center's

Materials Processing Laboratory has developed several facilities for reduced gravity experimentation on the NASA KC-135 aircraft, which flies a series of parabolic maneuvers to simulate reduced gravity. Although each parabola constitutes only 20-25 seconds of reduced gravity (0.01g), experiments can be designed to optimize the information obtained and to determine the feasibility of performing a similar experiment in space.

Other operations resulting from interaction with materials research at the Marshall Center include several manufacturing-related activities in conjunction with the Alabama Center for Advanced Technology Training (ACATT) in Huntsville. R&D projects include robotics, nondestructive testing of industrial products, and instrumentation. For example, after consulting with Nondestructive Evaluation Laboratory personnel at Marshall, UAH and Onan Corp. in Huntsville demonstrated a robotic ultrasonic scanning system for determining debonded regions in cast aluminum engine blocks and the wrought iron inner sleeve for the combustion chamber. Funding is currently being sought to move the technology from the laboratory to production.

The Consortium for Materials Development In Space (CMDS) provides for commercial materials development through several university-industry projects. Access to space is accomplished via NASA's various experimental facilities. Of particular interest to the CMDS are sub-orbital rocket flights that provide extended reduced gravity environments.

CMDS manages two rocket activities: the Consort program, which provides more than seven minutes of reduced gravity at less than 10^{4} g for a payload up to 650 pounds; and the Joust program, which will provide 14 minutes of low-g for a 520-pound payload.

The suborbital rocket activity is one example of commercial infrastructure supporting the basic materials objectives of the consortium. Another is a Univiveral Small Experiment Container (USEC) being designed for use in Spacelab or Spacehab, when either is carried aboard the shuttle, as well as in the shuttle middeck.

UAH's Center for Applied Optics (CAO) recently created the Laser Applications Research Laboratory (LARL), which provides Alabama's industrial community with a unique facility for testing and developing specialized applications of high-power lasers. The centerpiece of this laboratory is a 20 KW CO_2 CW laser donated to the university, in part, by Combustion Engineering. Its power is continuously tunable, so that it can emulate any commercially-available CO_2 laser. As a result, industries working with LARL can determine the applicability of lasers to their work with little investment in hardware.

CAO encourages industry to use the laboratory for research, development, trial runs, or prototype development involving laser-oriented materials handling problems. The types of R&D supported by LARL include drilling, cutting, welding, heat treating, cladding, and alloying of metal work pieces. A contract with a local small business will demonstrate at LARL laser brazing of ceramic material. Other projects focus on beam control and basic laser development. The CO_2 laser is computer-controlled and can produce an output beam of 1 to 20 KW power for durations of 0.1 second to hours.

LARL will receive in the near future two of the world's most powerful XeCl

A SPACE CAMP trainee "flies" the MMU against the backdrop of a mockup of the Hubble Space Telescope during an exercise at the U.S. Space & Rocket Center in Huntsville, Alabama. Enrollment is under way for youth and adult programs. Phone (205) 837-3400 for information. (Photo by Bob Gathany)

excimer lasers. One, with a Raman cell, will produce 540 nm radiation at 4 joules/pulse. The other will produce 308 nm radiation at 60 joules/pulse. Both are pulsed at 50-60 Hz.

Space Power Institute Involved In "Star Wars" Technology

Auburn University's Space Power Institute, formed in 1985, tackles a broad range of issues which impact on space power technology. Current research efforts concentrate on Strategic Defense Initiative (SDI) requirements. A totally new capacity will result, which should clearly define synergistic effects of spacecraft dynamics, power-produced vibration, thrust effluent, and local environment. New energy storage concepts based upon molecular engineering promise to produce orders of magnitude improvements in energy storage and utilization which will impact key issues of weight, volume, and cost.

The institute's approach to space power technology is to model spacecraft power train interactions to determine effects due to vibration, thrust, torque and effluent using finite element techniques developed for NASA and the aerospace community and plume modules from other sources; to model and build scale versions of power distribution within the spacecraft to determine optimum arrangements, operating parameters, reliability, necessary redundancy, and thermal effects; to conduct experiments with materials suitable for solid state switching in order to minimize thermal loss while maximizing power flow; to explore materials technology for use in energy storage devices and build prototype storage units by engineering large surface area materials, new electrolytes, and foils; to study electrical breakdown in the vacuum/spacecraft environment using gas species typical of spacecraft effluent; and to evaluate advances in power technology.

Supercomputing In Alabama

Alabama was the first state to fund and operate a high-speed supercomputer network for the dual purpose of promoting academic research and industrial development. The Alabama Supercomputer, a giant problem-solver capable of performing 400 million calculations per second, has been installed in its own 30,000 square foot building in Huntsville's Research Park West.

The Supercomputer Authority, a public corporation consisting of members of government and the private sector, oversees operation of a Cray XMP-24 supercomputer which is linked via high-speed (1.54 million bits per second) communication lines to Mobile, Montgomery, Birmingham, Tuscaloosa, and Auburn. Other links (56,000 bits per second) include Troy, Jacksonville, and the Shoals area.

Alabama's system is unique in that it requires 40 percent of its resources to be set aside for Alabama business. Access to the supercomputer makes engineering and scientific research possible which otherwise could not feasibly be accomplished.

Southern Research Institute Provides Creative Industrial Research

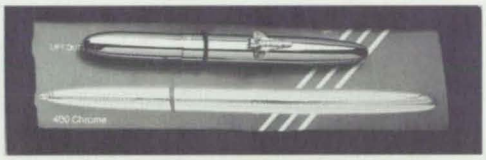
Birmingham's Southern Research Institute is providing local and regional industry with a new research and problem-solving service through its Division of Industrial Effectiveness. Bob Jeffcoat, head of the division, recalls a typical case in which a local manufacturer called him with an urgent problem—his usually high-quality paint finish

High-Tech Gift Ideas

Illustrated Encyclopedia Of Space Technology
A must for space buffs! The most comprehensive single-volume reference work on the history of space exploration. Hundreds of full-color illustrations reveal how the latest hardware works. 304 p. $29.95

The Universe: A Journey Through Space And Time
Join narrator William Shatner on a journey to the farthest reaches of the universe. Travel back billions of years and watch the evolution of stars and galaxies. This video adventure explores the universe's greatest mysteries: black holes, pulsars, quasars, and much more! Full color. VHS. 30 minutes. $34.95

The Space Pen
Developed for Apollo astronauts, this amazing pen writes at any angle (even upside down), in severe temperatures, and under water. Its patented pressurized cartridge lasts three times longer than ordinary cartridges. Compact chrome pen features distinctive space shuttle emblem. $15.95



NASA Shirt/Cap Combo
Special offer: High-quality white cotton/poly golf shirt and red-white adjustable cap...both featuring official red NASA logo. Only $23.95 for the set! (Shirt available in adult sizes only.)

Astronaut Ice Cream
The same ice cream enjoyed by astronauts in space. Freeze-dried, vacuum-packed, in a Neopolitan flavor mix: vanilla, chocolate, and strawberry. The perfect stocking stuffer! Two packages for $5.95

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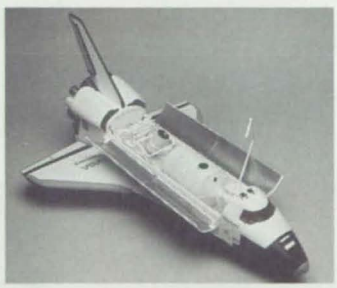

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was suddenly deteriorating, and tons of sheet steel were becoming scrap. Within hours they responded and identified the problem as a contaminant in the paint, a problem the manufacturer could solve at the source.

When the job calls for detective work, Southern Research acts like a consultant. But what makes this group unique is that it goes far beyond consulting to design products, invent production methods, and build machinery. It routinely employs computer-based methods for design, analysis, control, and simulation. The institute's production machinery incorporates digital control, advanced sensors, and various unconventional techniques for cutting and joining. Further, it uses state-of-the-art methods in such areas as quality improvement, inventory management, production planning, training, and decision support.

Research is continuing in the institute's traditional areas such as environmental protection, advanced materials, and drug development. In the latter area, an anticancer drug called Fludarabine is undergoing successful clinical trials and has been licensed to Triton Biosciences, Inc. It is the institute's tenth clinically evaluated drug and if commercialized would become the fifth commercial anticancer drug developed at Southern Research.

Resource Center Sells Alabama To Industry

The process of selecting a site for a business expansion or relocation can be an exhausting one, usually involving months of research as well as visits to numerous prospective locations. Alabama Power Company, through its Alabama Resource Center, offers an effective, time-efficient way to research and identify just the right site.

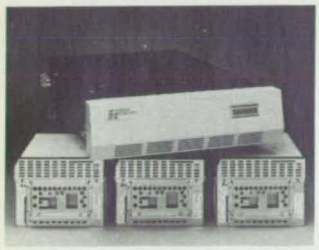
The center, located in the Meadowbrook Corporate Park 11 miles south of Birmingham, works closely with state and local economic development agencies to provide a one-stop, in-depth response to a full range of informational needs. The heart of the center is a presentation room which houses an interactive computer/laser disc system where a client can match project specifications against comprehensive databases. The databases contain video overviews of the business climate and quality of life in Alabama's communities; profiles of business and industrial parks and sites; data on available industrial and commercial buildings with aerial photography of each; infrared satellite photography of the state; a catalog of 52,000 U.S. Geological Survey maps at four scales; digitized quad sheets with current traffic counts; and census data, demographic trends and economic projections.

When potential sites are selected, a helicopter is available to take the client to each site. In 1989, the center hosted 92 prospect visits, aided in the preparation of 135 research reports and presentations for off-site delivery, prepared 1057 demographic reports, and handled 124 requests for specific data. It also hosted 14 economic development workshops and five leadership forums. ❑

For further information on science and technology in Alabama, please call the Alabama Department of Economic and Community Affairs' Science, Technology and Energy Division at (205) 284-8950. For business development in Alabama, contact the Alabama Development Office at 1-800-248-0033.

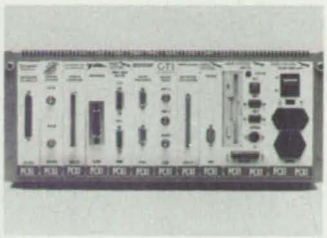
New on the Market

Storage Concepts, Irvine, CA, is offering the first commercial **parallel transfer disk (PTD) drives** combining the two fastest platforms - disk drive arrays and parallel transfer disks - for high capacity data storage. The Concept 161 System provides over 20 gigabytes of hard disk storage, with a peak data transfer rate of 50 megabytes per second, or 48 megabytes per second sustained, and can be connected to most host computers.
Circle Reader Action Number 774.



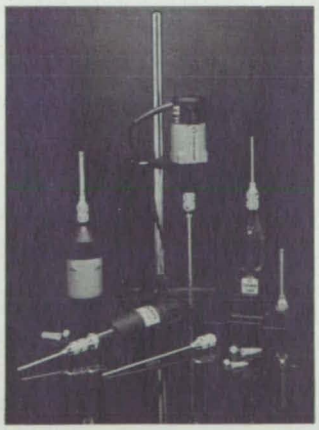
The Magneto-Optic/EddyCurrent Imager (MOI) from PRI Instrumentation, Torrance, CA, provides a **new method for fast inspection and detection of fatigue cracks and below-surface corrosion in aging aircraft.** Large areas can be examined rapidly by moving the camera unit across the metal surface. A miniature CCD camera inside the handheld inspection unit displays a clear image of rivets, cracks, and corrosion on a portable TV monitor. The images can be videotaped to document results.
Circle Reader Action Number 766.

A 100 megabits per second **communication controller** designed for the UNIX multiuser graphics marketplace is available from Comtrol Corp., St. Paul, MN. Dubbed MultiVision, it enables a user to connect up to 16 graphics stations to any 386- or 486-based AT- compatible microcomputer. A MultiVision graphics station can run any application designed for the "X" environment.
Circle Reader Action Number 770.



The PCXI **modular industrial PC** from Rapid Systems, Seattle, WA, is suited for rugged test applications. It accepts any PC instrumentation, data acquisition, or control cards manufactured to the Industry Standard Architecture (ISA). These cards are mounted in EMI/RFI shielded modules that plug into a passive backplane. A typical PCXI consists of a power supply, CPU and video modules, plus up to eight modules containing instrumentation cards.
Circle Reader Action Number 768.

Omni International, Waterbury, CT, has introduced a line of **handheld mechanical homogenizers.** The homogenizers combine the precision to process samples as small as 0.03 ml with the power to process over 20 liters. Applications include RNA preps and processing samples in microcentrifuge tubes.
Circle Reader Action Number 772.



RPlot™ from Research Software, New York City, is an **MS-DOS utility for plotting scientific data.** The software uses ASCII data files created by data acquisition systems or theoretical computer codes; no file conversion is needed. Within each file, RPlot automatically handles a range of formats including multiple data sets and textual comments. It creates publication quality figures including error bars, logarithmic axes, multiple fonts, superscripts, subscripts, scientific symbols, and the Greek alphabet.
Circle Reader Action Number 776.

New Literature

"Wireless/90," a free catalog from Microwave Filter Company Inc., East Syracuse,NY, describes **microwave filters and accessories** for MMDS/ITFS/MDS reception, including video aural combiners, channel combiners, preselectors, and interference filters. It details the evolution of the wireless cable industry, its equipment, and the nature of this video delivery system. An appendix lists domestic and international channel frequencies.
Circle Reader Action Number 714.

An eight-page color brochure from Perkin Elmer, Norwalk, CT, introduces the ELAN 5000, an **inductively-coupled plasma mass spectrometer .** This compact system is designed for rapid multielement determination of elemental species at low concentrations in a variety of samples. The brochure summarizes the ELAN 5000's features, including its single-button control of the vacuum system and ICP, and the built-in free-running 40 MHz RF generator specially designed for ICP-MS, which ensures the lowest possible oxide levels.
Circle Reader Action Number 724.

A 20-page brochure by Instron Corporation, Canton, MA, details a line of microprocessor-based **load/strain measuring instruments**, fast-acting grips and fixtures which improve productivity on high-volume testing applications. All models are easily automated using PCs for test control, data collection, and analysis, including SPC and SQC. The six models featured provide capacities from 1125 to 135,000 pounds for applications ranging from low modulus, extensible materials such as rubber and textiles to tougher plastics, metals, and composites.
Circle Reader Action Number 716.

Texcel Inc., Westfield, MA, is offering a free brochure on the TXL-9000, a fully integrated **laser hermetic sealing system**. Designed for the instrument and control, biomedical device, and defense electronics industries, it enables the hermetic sealing of products in a dry, inert, controlled atmosphere. Specifications of the glovebox, CNC, positioning hardware, and laser are listed.
Circle Reader Action Number 726.

The Daedal Division of Parker Hannifin Corp., Harrison City, PA, has released a reference guide covering the company's complete line of **positioning systems and components**, including cross roller and ball bearing slides; center and side drive cross roller tables; micrometer stages; half-step, microstepping, and servo motor drives; computer-interfaced motion controllers; and optical positioners and hardware. The 200-page catalog features design specifications, product descriptions, and updated pricing.
Circle Reader Action Number 722.

Hardman Inc., Belleville, NJ, has published a six-page **adhesive selector guide** which describes typical uses and includes an adhesive applications selector chart for the Double Bubble ® line of single-use adhesives. A range of epoxy, urethane, acrylic, and silicone formulations are discussed for maintenance, repair, and production applications. The selector chart lists such performance characteristics as work and handling time, service temperature range, and performance on various substrates.
Circle Reader Action Number 720.

The Norwegian Electronics Type 110 Sound Analyzer, **a portable sound and vibration analyzer**, is illustrated in a 20-page brochure published by Scantek Inc., Rockville, MD. The instrument combines the features of a sound level meter, environmental noise analyzer, frequency analyzer, graphic level recorder, and reverberation time analyzer. It measures 2-1/4 inches by 6-1/2 inches and weighs less than five pounds.
Circle Reader Action Number 718.

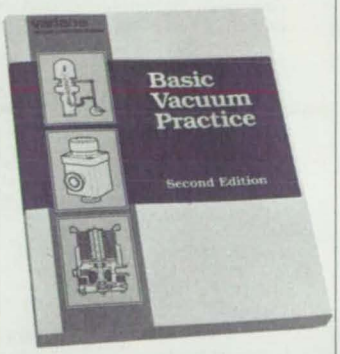
New Literature

A full-color brochure from Moritex USA, San Diego, CA, describes the SCOPEMAN handheld **video microscope imaging system**, which enables users to image almost any subject from 1 to 1800 power. SCOPEMAN's camera, lens, and lighting are integrated in a flexible probe that can be taken to the subject, eliminating the need for destructive and time-consuming sample preparation. The brochure lists available accessories and includes application photos.
Circle Reader Action Number 704.

Keithley Instruments, Cleveland, OH, has published a 12-page brochure that reviews factors to consider when buying or designing **Hall Effect measurement systems**, such as temperature effects, resistance range, and the advantages of DC versus AC systems. The free brochure highlights integrated solutions to making accurate Hall Effect and related measurements of bulk semiconductor materials such as silicon samples, III-V compounds, II-VI compounds, and the latest high-temperature superconducting materials. Schematic drawings are included for each solution.
Circle Reader Action Number 702.

An eight-page brochure from Applied Microsystems Corp., Redmond, WA, introduces the EL3200, a 33-60 MHz **microprocessor emulator** for Sun workstations or personal computers. It describes the system's ability to handle fast speeds and new chip architectures such as the 68030. Other features include a modular design, menu-driven emulator control software, real-time programs to help with debugging, and up to 2 MB of stackable memory overlay modules.
Circle Reader Action Number 712.

Basic Vacuum Practice, a new manual from Varian's Vacuum Products Division, Santa Clara, CA, covers **vacuum concepts**, commonly-used vacuum pumps, general pump maintenance, and components such as gauges, materials, seals, valves, and feedthroughs. Other features include pump-down and back-to-air directions for bringing common vacuum systems on line; tips on cryopump regeneration; and a discussion of oil-free mechanical pumping.
Circle Reader Action Number 706.



Diversified Optical Products Inc., Salem, NH, has released a catalog featuring standard **lenses, windows, domes, and beam expanders** for use in the ultraviolet, visible, and infrared region from 1-15 microns. The catalog also provides information on standard infrared antireflection coatings.
Circle Reader Action Number 708.

Resin systems and typical applications are highlighted in a 24-page brochure from Fiberite Composite Materials, Tempe, AZ. It includes information on thermosetting resins, toughened epoxy resins, Toolrite(r) composite tooling, Karbon(r) carbon/carbon materials, interior resins systems, APC-2 thermoplastic composites, ablatives, weaving, and engineered textile structures. A resin selector chart enables readers to quickly locate specific products and applications.
Circle Reader Action Number 710.

Subject Index

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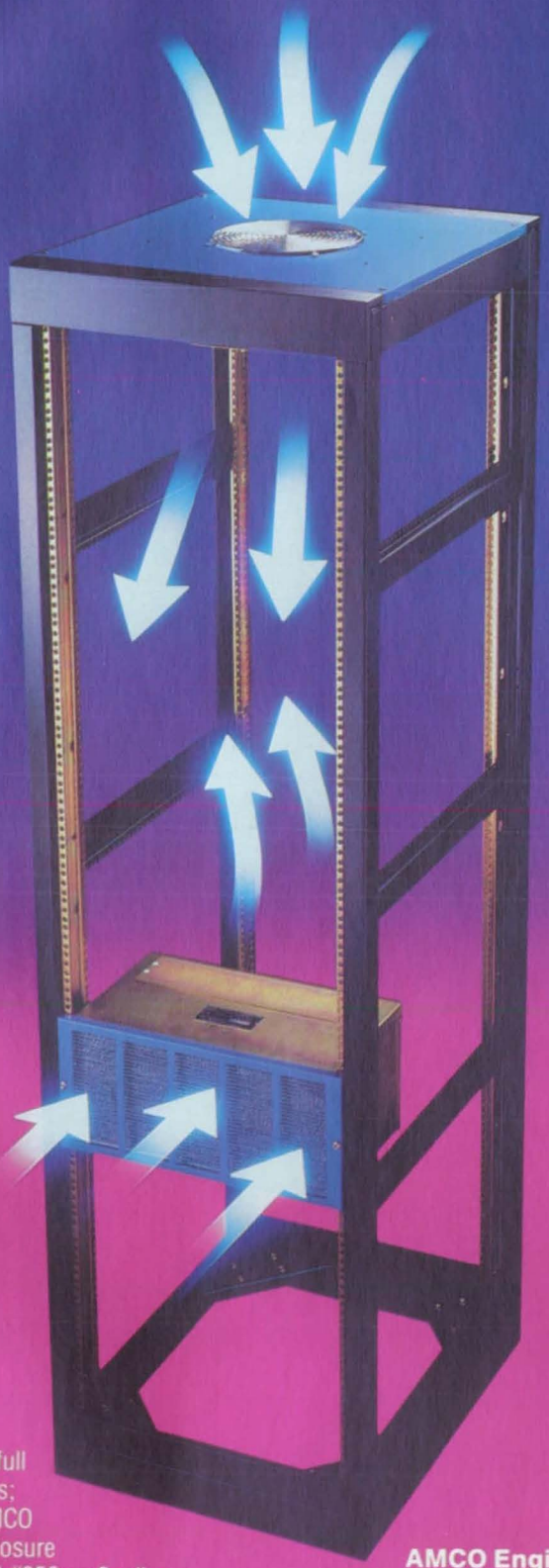

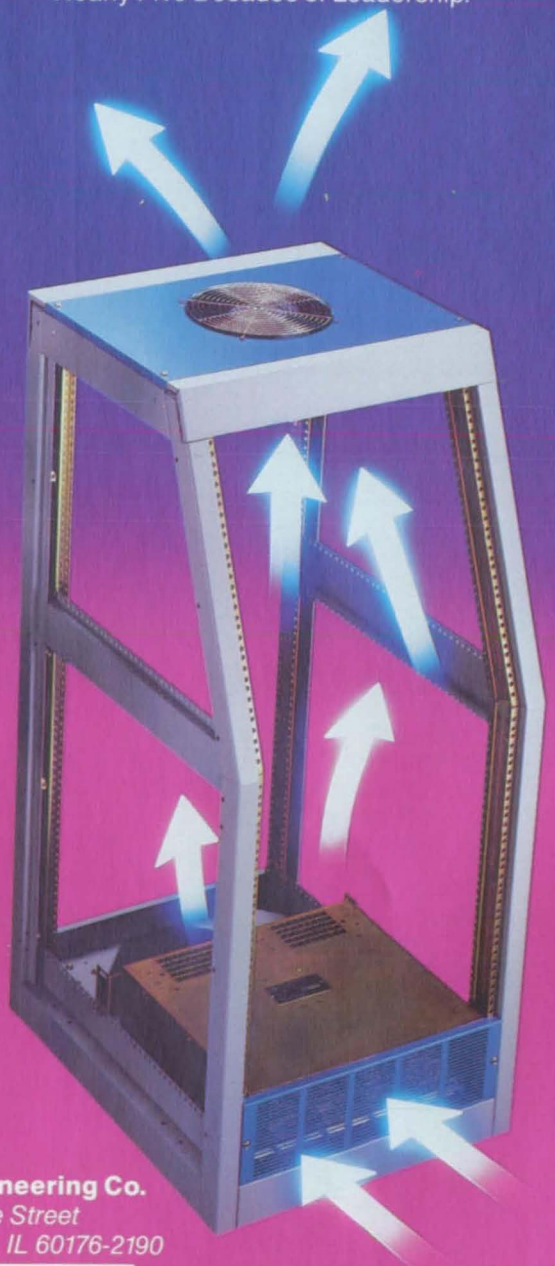

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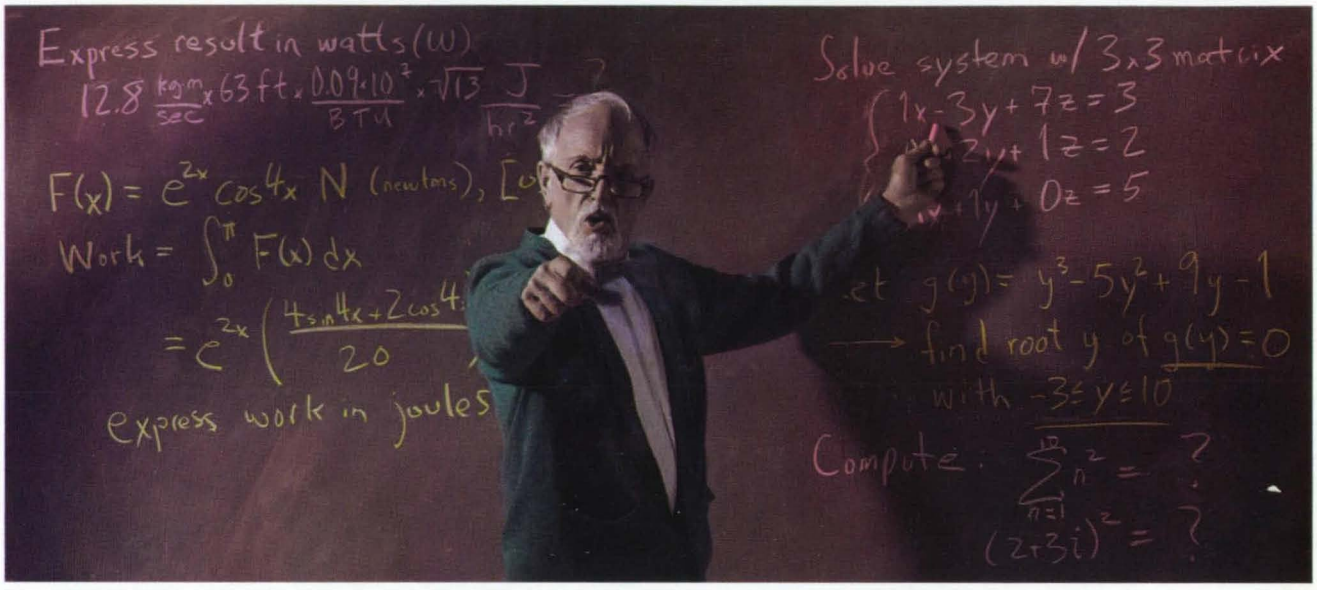

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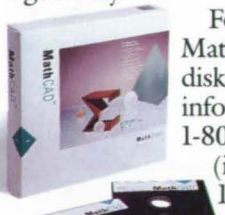

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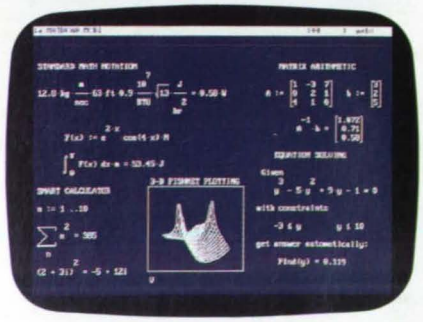

MathCAD 2.5 includes 3-D plotting, HPGL sketch import, and PostScript output.

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MathSoft, Inc., 201 Broadway, Cambridge, MA 02139

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